ISSN 1995-6983
www.jaebd.com

Journal of Agroforestry and Environment

December 2017
Vol. 11 No. 1 & 2

Official Publication of
Agroforestry Society of Bangladesh

Journal of Agroforestry and Environment

Research Journal of Agroforestry Society of Bangladesh

Volume 11 **No. 1 & 2** **December 2017**

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Journal of Agroforestry and Environment

Volume 11	Number 1 & 2	December 2017

Content

These theses are related to activities of the Department of Practice-oriented area studies, Kyoto University and two international workshops held in Yangon, Myanmar, 13-14th, February 2012 and Hathia, Bangladesh, 6-7th, March 2013. Other theses included in the journal of this volume is not contained here.

J. Agrofor. Environ. 11 (1 & 2): 1-14, 2017 ISSN 1995-6983

Fishing gears around Lam Se Bai, a tributary of the middle Mekong river basin

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Abstract: This study demonstrated fisheries and fishing gears around Lam Se Bai which is one of the secondary tributaries of the middle Mekong river basin. Fisheries in the Lam Se Bai basin were exclusively small-scale and were considered as a kind of community-based routine activities for local inhabitants. The fishing activities were dependent on seasonal patterns of flooding and recession of water level, and a lot of unique fishing gears have been developed through generations of their fishing experience and knowledge on fish behaviors and habitats. In a series of our field surveys, a total of 62 kinds of fishing gears and the related tools were recognized in and around the Lam Se Bai basin. They were classified into four categories; 16 net fishing gears, 29 trap fishing gears, 3 hook fishing gears, 8 other miscellaneous fishing gears and 6 related tools. Some fishing gears were in common with everywhere else in Thailand and others were indigenous fishing gears developed predominantly in the Lam Se Bai basin; for example, stake net trap, branch weir trap, bamboo screen trap, basket traps and cylinder traps. Indigenous fishing gears were traditionally made of materials available locally and easily obtainable, and some of them were designed for a particular hydrological environment and/or target species. Structures and fishing methods of every fishing gears and the related tools observed in and around the Lam Se Bai basin were described with pictures.
Key words: Fishing gear, indigenous fisheries, fishery resources, inland fisheries, Mekong river.

Introduction

The Mekong is the world's 10th longest river which flows over 4,900 km^2 through six countries; China, Myanmar, Laos, Thailand, Cambodia and Vietnam. Local inhabitants living along the basin are exclusively associated with the huge water system of the Mekong river and the numerous tributaries. For the local inhabitants, a variety of hydrological systems of rivers, tributaries, channels, canals, swamps, ponds, reservoirs, floodplains and paddy fields are important not only for the site of their daily living but also the ground to obtain natural resources for supporting their livelihood (MRC 2001, 2007).

The Mekong river basin is considered to support the richest inland fishery resources in the world and the estimated annual production of capture fisheries is 2.1 million tons of which estimated price is 2.1-3.8 billion US$ (Dugan *et al.*, 2010), in which 0.9 million tons and 0.7 billion US$ are recorded in Thailand (MRC 2007). Fish and other aquatic organisms are main source of animal protein for the local inhabitants of the Mekong river basin, particularly those who live in rural areas, and about 50-80 % of protein are considered to obtain from fishery resources (MRC 2001, Dugan *et al.*, 2010). In addition to the direct contribution of fisheries for their livelihoods, there are many additional economic benefits from engaging in fish processing and marketing.

For various fishing activities, a lot of unique fishing gears have been developed through generations of fishing experience and knowledge of fish behaviors and habitats in the Mekong river basin. Southeast Asian Fisheries Development Center summarized approximately 150 kinds of coastal and offshore fishing gears in Thailand and classified them into 12 major categories (SEAFDEC 2004), but there was little description about freshwater fishing gears. Mekong River Commission reported about fisheries of the middle Mekong river, particularly in Thailand (MRC 2007). Although they mentioned more than 150 types of fishing gears were recognized throughout the river basin, only 22 kinds of fishing gears were presented (MRC 2007). Ubon Ratchathani Regional Forest Office presented pictures of about 10 fishing gears found in the tributary of the middle Mekong river (URRFO 2007). Thai Baan Research Network summarized fisheries and fishing gears in Songkhram river which is one of the branch of the middle Mekong river (Friend, 2005). Iwata (2002) and Iwata *et al.* (2003) summarized fishing gears found in Laos of the middle Mekong river. Punswarn (2005) and Tapkorn (2010) demonstrated various freshwater fishing gears predominantly observed in the central parts of Thailand.

Despite a lot of unique and indigenous fishing gears were found in the tributaries and the floodplains in the Mekong river basin, the knowledge has been still limited thus causing difficulties for the management and conservation of fishery resources in recent years. We demonstrated in this study that fisheries and fishing gears around the Lam Se Bai basin which is one of the tributaries of the middle Mekong river.

Materials and Methods

In the northeastern Thailand, there is an extensive hydrological network consists of a lot of rivers and reservoirs of the Mekong river basin, in which the Lam Se Bai is one of the tributaries (Fig. 1). The stream of the Lam Se Bai starts from the northern hilly terrain of Yasothon and Roi Et provinces, in which the main headstream is originated from hillsides of Phu Pha Nam Yoi (16°19'56.7"N, 104°19'13.7"E, 421 m above SWL), Phu Choko Hin Kong (16°22'07.3"N, 104°22'42.2"E, 445 m above SWL) and Phu Tham Yang Diao (16°21'46.0"N, 104°24'21.0"E, 411 m above SWL). The stream flows toward southward and connects to the Mun river near Ban Kut Chum village (15°14'26.0"N, 104°46'48.0"E 110 m above SWL), Ubon Ratchathani province. The straight-line distance from the origin to the intersection is about 130 km and the main stream is assumed to be about 270 km. The Mun river is one of the main tributaries of the middle Mekong river basin, and therefore, the Lam Se Bai is one of the secondary tributaries of the Mekong river.

The Lam Se Bai is conveniently divided into three parts: upper, middle and lower streams. The upper Lam Se Bai is the area from the origin to around the Kut Peng reservoir, the middle one is from there to the Pa Ao dam and the lower one is from there to the intersection to the Mun river. In the middle part, the river flows on the border between Yasothon and Amnat Charoen provinces at altitudes

between 110 and 120 meters above mean seawater level. Extensive riparian swamps, floodplains, paddy fields, dry lands, orchard gardens, community forests and small villages are distributed in this areas (Sano *et al.*, 2011). The middle Lam Se Bai diverges into a lot of small branches and streams, and make a hydrological network, including reservoirs, ponds and swamps. For these branches and streams, a lot of names are given; for example Lam Se Noi, Lam Pla Daek, Lam Phong, Huai Sam Kha, Huai Khamen, and so on.

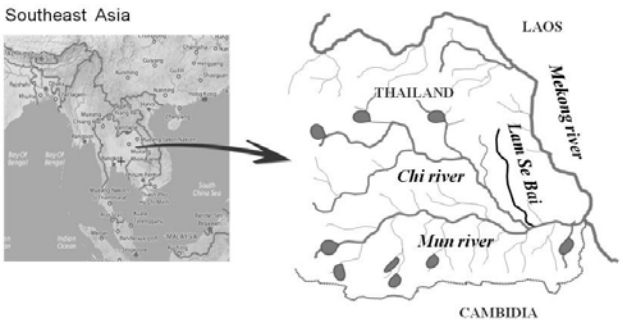

Figure 1. Map of southeast Asia and northeastern Thailand. Lam Se Bai is one of the secondary tributaries of the middle Mekong river basin.

The hydrological conditions in the middle Lam Se Bai basin were characterized by seasonal patterns of flooding and recession, in which the rivers flooded frequently during the rainy season between June and October (Fujioka *et al.*, 2011). The water level at the Lam Se Bai dam fluctuated more than 9 m from about 113 m to 122 m above mean seawater level (Fujioka *et al*., 2010). When water level of upper dam (Lam Se Bai Dam) exceeded 118 m above mean seawater level, dam gates opened to avoid water flood in the upper areas.

For about three years from 2009 to 2011, we investigated fishing activities and environmental conditions mainly in the middle Lam Se Bai (Fujioka *et al.*, 2010, 2011, 2012). We selected this areas because various traditional fishing activities have been still carried out even now. During our field surveys, we found a lot of indigenous fishing gears throughout the Lam Se Bai basin from the headstream to the lowest end where it connects to the Mun river. In this report, we demonstrated fishing gears observed in and around the Lam Se Bai. Almost all the pictures shown in this report were taken within the Lam Se Bai basin, but some pictures taken at the adjacent areas; for example, Chi river and Mun river, were also used to explain clearly the characteristic of fishing gears.

Results and Discussion

In the Mekong river basin, commercial fisheries were developed and most of fisheries products were traded as fresh fish in local market or as processed products to brokers (MRC 2001, 2007). However fisheries in the Lam Se Bai basin were exclusively small-scale and fishermen preferred compact and simple fishing gears because most aquatic habitats were too small to introduce large fishing gears. Trawl, surrounding net, seine net, big bag net and other large fishing gears were hardly found in this area. Fisheries in the Lam Se Bai basin were not commercial but were considered as a kind of community-based routine activities for local inhabitants.

The behavior of fishes depended largely on complex interacting relationships among annual floods, recession and natural flow patterns, in addition to the extent and quality of flooded forest and the variety of swamp ecosystems. A lot of fish species living in the trunk of the mainstream migrated to the tributaries during the rainy season for feeding, breeding and nursing (Paulsen *et al.*, 2002). Among 850 fish species recorded from the Mekong river basin, 135 of which migrated within the river on certain stages of their life cycle (Dugan *et al.*, 2010). In the Songkhram river basin which was the longest tributary of the middle Mekong basin, 58 species out of 124 fish species migrated for feeding and spawning from the Mekong mainstream into tributaries from May to July (Friend, 2005). Thus, the seasonal flooding was largely concerned with fishing activities by local inhabitants in the Lam Se Bai basin.

Fishery resources provided fundamental ecological services for local inhabitants living along the Lam Se Bai basin. Local inhabitants have adapted their livelihoods over the years to utilize the fishery resources based on a deep understanding of fish migration patterns, feeding and spawning, flood patterns and fish habitats. A lot of fishing gears have been developed through generations of their fishing experience and knowledge. Thereby the efficient use of the indigenous fishing gears depended on understanding of fish behaviors, habitat and seasonal environmental conditions, and as the results local inhabitants can utilize sustainably fishery resources. They sometimes made an agreement by themselves to conserve fishery resources to keep them in sanctuary.

In the present study, a total of 62 kinds of fishing gears and the related tools were recognized in and around the Lam Se Bai basin. They were classified into four categories; 16 net fishing gears, 29 trap fishing gears, 3 hook fishing gears, 8 other miscellaneous fishing gears and 6 related tools. Some fishing gears; for example, gill net, cast net and scoop net, were in common with everywhere else in Thailand (SEAFDEC 2006) and other countries (FAJ, 1996, Kaneda, 2005), and others were indigenous fishing gears predominantly developed in the Lam Se Bai basin; for example stake net trap, branch weir trap, bamboo screen trap, basket traps and cylinder traps.

Indigenous fishing gears were traditionally made of materials available locally and easily obtainable, such as bamboo, branch, wood, rattan, ivy and stone, and some of them were designed for a particular hydrological environment and/or target species. Nowadays, some industrial materials such as nylon net, polyethylene net and rope, polyvinyl chloride (PVC), fiber reinforced plastic (FRP), polystyrene and plastic were used because of their advantage of low cost, easy operability and good permanence. Although fishing has evolved with the development of fishing gear and fishing operations, many fisheries experts believed that the increasing use of modern fishing gears is one of the major threats confronting the Mekong's fishery resources (MRC 2007).

Structures and fishing methods of every fishing gears and the related tools observed in and around the Lam Se Bai basin were described as follows. Pictures of every fishing

gears were also exhibited in colored plates at the end of at the end of description of each fishing gear.

Gill net (Mhong, Khai): Gill net is one of the most popular fishing gear for small scale fisheries along the Lam Se Bai as well as other river basin. A net wall, with its lower end weighted by sinker and the upper end raised by floats, is transversely set toward the path of migrating fishes at certain depths from the upper to the lower layers. Fishes are tangled up in the net. The net is sometimes fixed with woody or bamboo poles to prevent it drifting. The mesh is rhombi formed made by monofilament nylon strings and usually one layer. The size of one lot is about 20-50 m long and 0.5-1.7 m high with the mesh size ranges from 10 to 30 mm, but the bigger net exceeds 4 m high with the mesh size 125 mm. Because of simplicity in its structure, principle, operation and low investment cost, fishermen prefer the gill net for routine fishing activities. Fishermen set gill net at evening and harvest in the next morning, but they can use it all the day round and all the year round. Gill net is sold in the market and the fishing tackle store. "Mhong" is the northeastern dialect and "khai" is the standard Thai language.

Gill net

Drift gill net (Mhong lai, Khai loy): During the rainy season, fishermen sometimes make gill net drifting in the river stream without fixing in certain place. A net wall is set across the water current and be allowed to drift according to the current direction. The upper lope is floating on the water surface and the lower part does not touch to the bottom. Polystyrol float, plastic float or polyethylene terephthalate (PET) bottle are used for floating the net. The mesh size varies 30-50 mm depending on target fishes. Fishermen usually operate the drift gill net on the small boat with or without engine. Drift gill net is found in the middle and the lower Lam Se Bai. "Mhong lai" is the northeastern dialect, in which "lai" means the net follow the water current. "Khai loy" is the standard Thai language, in which "loy" means floating on the water.

Drift gill net

Handy surrounding net (Dang): The word "dang" is sometimes used for comparatively large gill net, but at the same time "dang" means a kind of surrounding net. The net is made by twisted cotton yarn, with its lower end weighted by metal chain and the upper end raised by floats. The mesh size ranges from 15 to 30 mm. In the shallow waters of rivers, reservoirs and ponds, fishermen surround some water areas, sometimes those around the bush shelter trap (No. 44), by means of handy surrounding net. Handy surrounding net is found throughout the Lam Se Bai basin. "Dang" is the northeastern dialect.

Handy surrounding net

Seine net (Uwan tub taling): A large scale fishing operated collaboratively by several fishermen by means of long nets and fishing boat. The net is made of twisted cotton yarn or nylon fiber, with its lower end weighted by sinker and the upper end raised by floats and the size is approximately 200 m long and 14-20 m high. One side of the net is set on the beach and another side is brought by fishing boat to surround water areas. Seine net is operated in the dry season when water depth and water current are reduced. We found seine net several years ago near the junction of the Chi river and the Mun river, but it is presently prohibited by the fisheries law in the river basin. Seine net is frequently operated in coastal waters (SEAFDEC, 2004, Kaneda, 2005). "Uwan" is the standard Thai language.

Seine net

Handy seine net (Pason, Payaeng, Uwan): Handy seine net consists of two bamboo poles and a shallow bag net between them. The net is made by twisted polyethylene fibers or cotton yarn, with its lower end weighted by metal chain. The mesh size ranges from 3 to 10 mm. Two fishermen handle the poles of each side and walk forward slowly to collect small fishes and other aquatic organisms. Handy seine net is operated in the shallow waters of rivers, reservoirs and ponds of the Lam Se Bai basin. Both "pason" and "payen" are the northeastern dialect and "Uwan" is the standard Thai language.

Handy seine net

Portable lift net, Four-armed scoop net (Sadung lek, Yor, Yor deun): Square shaped small liftnet which made of twisted polyethylene fibers and bamboo framework. Every corners of the net connect individually to curved

arms and are suspended by a long bamboo rod. Fishermen manipulate it by themselves to lift and down in the shallow waters of riverside, ponds and reservoirs. Rice bran and fermented fish meat are sometimes set in the center of the net to attract fishes, but the bait is unnecessary when it is used on the fishway. After sinking it slowly into the water, they wait several minutes, and finally draw up from the water to scoop small fishes. Water depth is less than about 0.5-2.5 m. It can collect every kinds of small fishes inhabiting the surface layers, such as river sprat (*Clupeichthys aesarnensis*), river abramine (*Paralaubuca* spp.), rasbora (*Rasbora* spp.) and other small cypronids. In the Lam Se Bai basin, portable liftnet larger than 2 m in diameter is prohibited by the fisheries law during the breeding season from 16th May to 15th September every year. Portable liftnet is found around Kut Peng reservoir and Pa Ao dam of the middle to the lower Lam Se Bai. "Sadung" is the northeastern dialect, while "yor" and "yor deun" are the standard Thai language, in which "deun" means walking. In some cases, "sadung" represents relatively smaller fishing gear than "yor".

Portable lift net, Four-armed scoop net

Lift net (Sadung yai, Yor prajam tee): Liftnet is a large boat-mounted fishing gear which is manipulated on the bamboo raft anchored near the riverside. The net is connected to the top of about 12-17 m long bamboo beam and operated mechanically by means of the rope and the lifting winch equipped on the raft. About 3-5 m square shaped net is suspended with four bamboo arms. The mesh size is 20-50 mm depending on the target fishes. Bamboo fence is sometimes used in order to guide fishes onto the liftnet. Fishermen put rice bran and fermented fish meat in the center of the net to attract fishes and submerge it near the bottom layer. After waiting certain times, they lift up the net over the water surface. Target is various small fishes inhabiting the middle to the surface layers, such as sheatfish (*Kryptopterus* and *Micronema*) and cypronids (*Cyclocheilichthys* and *Barbonymus*). Large liftnet is hardly found in the Lam Se Bai basin, but it is frequently observed in the middle Chi river. "Yor prajam tee" means a permanent fishing equipment.

Lift net

Mobile pushnet, Boat dip net (Chorn sanan): Mobile pushnet is an indigenous boat-mounted fishing gear operated widely in the Mekong river basin. It consists of two main components that are a net and a triangle bamboo frame of more than 10 m long. The net is made by twined fiber with the mesh size is about 30-40 mm, and the mouth of it is linked to open widely by means of the bamboo frame. The bamboo frame is fixed to the head of boat and manipulated mechanically to lift and down by means of the rope and the lifting winch. Mobile pushnet can be operated only on the flat sandy or muddy substratum. Every kind of fishes are collected from nearly bottom layer to the surface layer during the engine-driven boat is pushing the net forward. Two fishermen ride on one engine boat, one for controlling the boat and the another operate the mobile pushnet at the head of the boat. Mobile pushnet is frequently operated around the Yasothon dam of the Chi river. "Chorn" is the standard Thai language.

Mobile pushnet, Boat dip net

Handy pushnet, Dip net (Chorn, Chorn ka keam): The structure and the usage are similar to the mobile pushnet, but handy pushnet is smaller and manipulated by only human power. The bamboo poles are about 2-4 m long and they can be collapsible. In the river and stream, local inhabitants manipulate it with or without boat throughout the year. Nothing bait is used when it is used on the fishway. Handy pushnet is observed at the lower Lam Se Bai basin. "Chorn" is the standard Thai language.

Handy pushnet, Dip net

Cast net (Hae): Cast net is the most popular portable fishing gears in the Lam Se Bai as well as other shallow waters in the Mekong river basin. Because of the simple structure and the low investment cost, fishermen prefer cast net for their routine small scale fisheries. Although the operation is required skill, it can be carried out by a single fisherman, with or without boat.

Cast net

The body is shaped as a bag and made by monofilament nylon string or twisted cotton yarn. The net size ranges 2-3 m long and 5-10 m in the circumference and the mesh size is about 20-30 mm. The top of the net has a line so that casting and hauling can be more easily. Metal weights (or chain) are connected to every 0.2-0.4 m intervals of the bottom margin to sink the net rapidly. Local inhabitants operate cast net during daytime throughout the year in every shallow waters of rivers, ponds, reservoirs and channels. "Hae" is the standard Thai language.

Drop net (Toan, Toan lee): A simple fishing method to collect small fishes and shrimps which are overflowed from weir of rivers and channels. Polyethylene net is set below the weir by means of woody and bamboo frameworks. Fishermen set continuously the drop net and sometimes collect fishes and shrimps from it by scoop net (No. 54). Drop net is found at Kut Hae and Kut Peng villages along the upper to the middle Lam Se Bai. "Toan" and "lee" are the northeastern dialect.

Drop net

Shrimp net (Sai khung): A specialized fishing gear to collect freshwater shrimps, predominantly *Macrobanchium lanchesteri*, in the river banks, reservoirs and floodplains during the rainy season. The net is approximately 0.5-0.6 m high and 1-1.4 m wide per one segment and is vertically stood by means of woody or bamboo poles. Shrimps are collected in the blind alley of the nets. Shrimp net is frequently operated throughout the Lam Se Bai basin.

Shrimp net

Small bag net (Tong pla): A simple fishing method to collect small fishes coming out from irrigation channels and paddy fields. Polyethylene bag net is set on the outlet of the drain. It is found at Kut Ching Mi village of the upper Lam Se Bai. "Tong pla" is the northeastern dialect.

Small bag net Bag net

Bag net (Pong pang): Approximately 20-50 m long bag net which is made of twisted cotton yarn or polyethylene fibers is installed to block the river stream with the entry facing upstream. Both side of net are connected to trees or poles. About 50-70 mm large mesh is used near the entrance to reduce water resistance, and the mesh size is gradually decreased toward backward and it becomes finally about 15 mm at the bottom end. The production is very large (*ca.* 20-30 kg/day), but it is possible to operate only several days in the peak of the rainy season. Bag net was formerly operated in the middle Lam Se Bai, but it is presently prohibited by the fisheries law. "Pong parn" is the standard Thai language.

Stake net trap (Pong pang, Jip yai): Stake net trap "Pong pang" is an unique indigenous fishing gear observed around Na Kae village of the middle Lam Se Bai. The structure of stake net trap consists of two main components that are wooden pole fence and a big bag net. The fences block the river stream and so that the pathway of migrating fishes to guide them into the bag net. The poles stands 5-9 m high above the riverbed. About 20-30 m long bag net is installed between pole fences in the center of the river with the entry facing upstream and every kinds of fishes going to downstream are collected by the net. Several fishermen operate collaboratively the stake net trap in the rainy season. The production is usually 10-30 kg/day and the maximum one is about 100 kg/day which can be sold about US$ 1,700 (53,000 bahts) in the market, but the suitable water conditions (water level and current speed) are restricted only a few weeks every year. Stake net trap is prohibited in the beginning of rainy season from May to August to conserve the fishery resources because a lot of migrating fishes come upstream for mating and breeding in this season (Paulsen *et al.*, 2002). Smaller mesh size than 30 mm is also prohibited by agreement among local inhabitants. A total of 25 stake net trap is presently installed along the middle Lam Se Bai. More detailed knowledge is described in Fujioka *et al.* (2011). "Pong pang" is the standard Thai language to express big bag net and "jip" is the northeastern dialect.

Stake net trap

Branch stake net trap (Jip): Smaller branch stake trap is called as "jip". Branch or bamboo fence arranged on the shallow floodplains with facing upstream to guide fishes into the central parts in which trap net is installed. The net is made of twisted cotton yarn or polyethylene fibers. Branch stake net trap is observed only in the peak of the rainy season at the shallow floodplains near the Lam Se Bai dam.

Branch stake net trap

Branch weir trap (Luan loub): Branch weir trap "luan loub" is an unique indigenous fishing gear observed within swamp forests of riparian floodplains in the middle Lam Se Bai. The structure consists of two main components, branch fence and fish traps. The branch fence (called as "luan") is made by dried branches of "hualing" tree (*Hymenocardia wallichii*) and is arranged vertically toward the river stream. The branch of this tree is suitable to make the fence because (1) it can be obtain easily in the swamp forest, (2) the form is stable for a long time and (3) the leaves do not fall even when the branch is dried. The height of the fence is about 1.4-1.8 m and it block the pathway of migrating fishes to guide them into the trap. Cylindrical shaped fish traps (called as "loub") is installed on the triangular opening near of the bottom of the branch

fence with the entry facing downstream. The trap is about 1.3-1.6 m long and 0.4-0.5 m in diameter and is made by rattan and covered by splitted bamboo, but cotton yarn or twisted polyethylene fibers are presently also used. A fist-sized stone is put on the trap with strings to prevent it drifting. The trap does not contain any bait and is continuously kept to collect any kinds of fishes inhabiting near the bottom layer. Every fisherman has 1-9 branch fences "luan", and a total of more than 200 "luan" may be arranged around Na Kae village of the middle Lam Se Bai. When collecting fishes, they dive into the water and bring the trap onto their boat. More detailed knowledge is described in Fujioka *et al.* (2011). "Luan loub" is the standard Thai language.

Branch weir trap

Bamboo screen trap (Jip lek, Jip noi, Fuak, Pok): The structure is same as the branch weir trap, but the size is smaller and the fence is made by bamboo screen. Fish trap is made of small bag net or bamboo trap with the entry is facing whether upstream or downstream. The trap is installed at shallow waters of small channels, rivers and floodplains and is popular throughout the Lam Se Bai basin. "Jip" is the northeastern dialect, whereas "fuak" and "pok" are the standard Thai language.

Bamboo screen trap

Marginal trap (Loub duk pla): Marginal trap is structurally similar to the former two traps, but in this gear, the fish traps are set inside of the fence. The fence is about 15 m long and 1.5 m high and is made by bamboo poles and cotton net of about 30 mm mesh size. Several cylindrical shaped fish traps are installed with the entry facing along the inner margin of the fence. Marginal trap is observed at the reservoir near Si Than village of the middle Lam Se Bai.

20. Door trap (Jun, Jun duk pla): Door trap "jun" is an indigenous fishing gear with the specific device to catch rather big fishes of catfish (*Pangasius*, *Hemibagrus*, *Bagarius*) and cyprinid carps (*Hampara*, *Barbodes*). The structure consists of two main components that are branch stake fence and gate trap.

Marginal trap

The gate trap is made by wood or bamboo and covered by net or splitted bamboo. When fish enter the trap, it touch the fine string which is vertically stretched in the center, and then the door will be suddenly shut because the supported pole is disengaged, so the fish can not escape from the trap. The size of a big trap is 2.4 m long x 2.0 m high x 0.8 m width, in which the entrance area is 0.8 x 0.4 m. Door trap is found in the floodplains around Na Kae village in the middle Lam Se Bai. "Jan" is the standard Thai language.

Door trap

Weir trap, Fishpound (Lee): Weir trap or fishpound "lee" is a kind of gate trap observed around paddy fields and irrigation canals. The trap is made by woody and bamboo fence which is arranged vertically toward the water stream to interrupt the fishway. A bag net or bamboo shelf is installed on the water exit between the fences. When water is flooded from the paddy fields in the rainy season, farmers collect every kinds of fishes, shrimps and other aquatic organisms by means of their own weir traps. Although big weir traps have been observed about 20-30 years ago in the Lam Se Bai basin, they are hardly found in the recent time. Big weir trap is found in Laos (Iwata, 2002, Iwata *et al.*, 2003), and typical huge weir traps can be observed around the Khon water fall of the Mekong main stream. "Lee" is the northeastern dialect.

Weir trap, Fishpound

Shrimp trap (Loub khung, Duk khung): Shrimp trap is a specialized compact fishing gear to collect small shrimps, predominantly *Macrobanchium lanchesteri*, in the river banks. The shape is cylindrical fan or rectangular box with the size is about 1.0-1.4 m long. The frame is made of splitted bamboo or steel which is covered by twisted polyethylene net. The trap is stand by means of bamboo pole with the slit-like entry facing whether upstream or downstream. Net fences are installed to guide the shrimp into the trap. Nothing bait is used under the running waters, but rice bran and fish meat are provided under the stagnant waters. Fishermen set shrimp traps in the evening and collect 2-3 times midnight mainly in the rainy season. Shrimp trap is frequently operated around the Yasothon dam of the Chi river.

Shrimp trap

Funnel basket trap (Sai): Funnel basket trap "sai" is one of the most popular indigenous fishing gear in the Mekong river basin. Long and cylindrical shaped fish trap is weaved by splitted bamboo and rattan with the size of 0.8-2.0 m long and 0.1-0.5 m diameter. The trap has two entrances; one is the narrow end and the another is the side of the trap. The entrance is funnel shaped and become bottle necked to prevent the escape of fishes after enter the trap. The trap is horizontally set in the shallow waters of rivers, streams, channels, ponds, floodplains and paddy fields to catch benthic fishes during rainy season. Rice bran and fish meat are sometimes put inside as bait, but they are unnecessary when the trap set on the fishway. The size, the form and the structure varies according to the target species; tube like trap (Sai tor), globe like trap (Sai loy), frog trap (Sai kob), and so on. Funnel basket trap is sold at the fishing tackle store in which the market price is about 6-19 US$ (200-600 bahts). Small funnel basket trap is used for interior decoration. "Sai" is the standard Thai language.

Funnel basket trap

Upright basket trap (middle layer type) (Tum, Tum pasew): Upright basket trap is an unique indigenous fishing gear frequently observed throughout the Mekong river basin. The trap is cylinder or bottle shaped and weaved by splitted bamboo and rattan. The fish entrance is opened at the bottom of the trap, and inside of the opening, there is pointed bamboo funnel which prevent the fishes escaping from the trap. The size varies from 1.2 to 1.8 m long and from 0.3 to 0.5 m in diameter. The trap is connect to a long pole and vertically set in the middle layer of shallow waters of rivers, streams, channels, ponds, reservoirs and swamps. Main target of this trap is silver rasbora (*Rasbora argyrotaercha*) and other small cyprinid carps inhabiting the middle layer. Natural organic matters such as rice bran, fish meat, molluscs, crabs, insects and sometimes dried buffalo dung are put inside as fish bait. In the rainy season, the trap is set midnight and collect in the morning, but sometimes keep for a few days. There are a lot of types according to the size, shape and the target fishes. The basket trap was traditionally weaved by local inhabitants themselves but recently sold in the market. "Tum" is the standard Thai language.

Upright basket trap (middle layer type)

Upright basket trap (bottom layer type) (Tum bong, Tum pla kod): Different from the former one (No. 24), this is a basket trap to collect fishes inhabiting the bottom layer. The shape is cylinder or bottle like and it is weaved by splitted bamboo and rattan. The fish entrance is opened at the lower side of the trap. The size varies from 1.0 to 1.5 m long and from 0.3 to 0.5 m in diameter. The trap is vertically set on the bottom of the shallow waters of rivers, streams, channels, ponds, reservoirs and swamps. Main target of this trap is river catfishes (*Hemibagrus* spp., *Bagarius* spp.), walking catfish (*Clarias* spp.) and spiny eel (*Mastacembelus armatus*).

Upright basket trap (bottom layer type)

Small basket trap (hanging type)

Small basket trap (hanging type) (Tum klom, Tum pla soi): Because of the compact structure and the low investment cost, small basket trap is very popular fishing gear for small scale fisheries in the Lam Se Bai basin. The trap is barrel shaped and weaved by splitted bamboo and rattan. The triangle or rectangle fish entrance is opened at the lower side of the trap. Inside of the opening, there is pointed bamboo funnel which prevent the escape of the fishes after enter the trap. Rice bran, fish meat, and other organic matters are put inside as fish bait. The size is from 0.3 to 0.5 m long and from 0.2 to 0.5 m in diameter. The trap is vertically hung in the middle layer of shallow waters of rivers, streams, channels, ponds, reservoirs and riparian swamps. Main target fishes are river sprat (*Clupeichthys aesarnensis*) and other cyprinid carps.

Small basket trap (bottom type) (Tum larn): This is the bottom layer type of the small basket trap. The trap is approximately 0.4-0.6 m high, bottle, barrel or bell shaped

and weaved by splitted bamboo or twisted polyethylene fiber. The trap is installed on the shallow waters of 0.2-1 m deep with rice bran and termite as fish bait. Main target fishes are *Mystus* spp. and *Heterobagrus* spp., but it can collect every kinds of fishes inhabiting the bottom layer.

Small basket trap (bottom type)

Grass bush trap (Sue noan gin): Cylindrical fish trap weaved by splitted bamboo, rattan and ivy with the size of 0.8 m long and 0.2 m in diameter. Glasses and branches are set inside of the trap and it is laid down on the substratum from 0.5-2.0 m deep without any bait. The trap provide habitats for botia (*Botia* spp.) and sand goby (*Oxyeleotris marmorata*). Glass bush trap is observed near the junction of the lower Lam Se Bai and the Mun river. The Thai name "sue noan gin" is originated from the meaning that "tiger can eat without any effort (sleep)".

Grass bush trap (Sue noan gin)

Eel basket trap (Eju): Compact basket trap specialized to catch swamp eel (*Monopterus albus*) at the paddy fields, channels and swamps. The trap is weaved by splitted bamboo and rattan with the size of 0.3-0.8 m in height and 0.2-0.4 in bottom diameter. Fish meat, smashed apple snail and crab are packed in cylindrical bait container (named as "kapor") and set it inside of the trap. The upside of the trap is kept over the water surface and covered by coconut shell or straw. Eel basket trap is sometimes observed along the Lam Se Bai basin. "Eju" is the standard Thai language.

Eel basket trap

Frog basket trap (Tum kob): A pot shaped small basket trap to collect frogs (*Rana* spp.) at the paddy fields and swamps. The trap is weaved by splitted bamboo and the rounding entrance is opened near the lower side. Rice bran, fish meat, and other organic matters are put inside as bait. The size is 0.3-0.4 m in height and 0.2-0.3 m in diameter. Frog basket trap is frequently observed along the Lam Se Bai basin. Frog basket trap is traditionally weaved by local inhabitants themselves but is recently sold in the market.

Frog basket trap

Upright shrimp trap (Tum khung): A compact and portable fishing gear to collect small shrimp (*Macrobanchium lanchesteri*) in swamps and riverside. The height is about 0.3-0.4 m and the frame is made by splitted bamboo covered with twisted polyethylene net. There are several entrances which are made from the tap of polyethylene terephthalate (PET) bottle. Rice bran is used as bait. Upright shrimp shrimp trap is sold about 1.4-1.9 US$ (45-60 bahts) in the market.

Upright shrimp trap

Pot trap (Thong): Pot shaped large fish trap observed in the Mekong river basin. The material and structure are is similar to those of the upright basket trap ("tum"), but the size is extremely larger (1.5-7.0 m in height and 0.6-1.2 m in diameter). The trap connects to wooden pole and stands vertically on the middle to the lower layers of the river to catch cat fishes, barbs and other benthic fishes. Rice bran, fish, chicken, molluscs, crabs and insects are used as bait. Although this trap is operated in large tributaries such as Mun river (MRC 2007) and Songkhram river (Friend, 2005), we have never found it in the Lam Se Bai basin yet.

Pot trap

Horizontal cylinder trap (Loub, Loub noan): Horizontal (or laying) cylinder trap is one of the most popular fishing gear operated along the Lam Se Bai basin. The shapes are various, but mostly cylindrical and are weaved by locally available materials such as splitted bamboo, rattan and ivy. The size varies 0.5-2.5 m long and 0.3-0.8 m in diameter depending on the target fishes and the environments. One or two entrances are opened on the bottom or side of the trap. Inside of the opening, it has pointed bamboo funnel which prevent to escape the fishes after enter the trap. The trap is laid on the substratum of river, reservoirs, ponds, swamps, paddy fields and floodplains. Fishermen select the installation site based on their knowledge about topography, water current and fish behavior. Fish bait is sometimes put in the trap, but it is unnecessary when the trap is used on the fishway. The trap is traditionally

weaved by local inhabitants themselves but recently sold in the market.

Horizontal cylinder trap

Vertical cylinder trap (Loub yuen, Loub tang): Vertical (or standing) cylinder trap is a variation of bamboo trap. The shape is cylindrical or beer barrel like and the size varies 0.3-1.0 m long and 0.2-0.5 m in diameter. It is made by rattan and splitted bamboo which is covered with twisted cotton yarn or polyethylene fiber. In the shallow waters of rivers, channels, reservoirs, ponds, swamps and floodplains, fishermen set the trap with or without bait at certain depths according to the target fishes and environments. The main target is cyprinid carps and barbs (*Paralaubuca*, *Barbodes*, etc.), catfishes (*Mystus*, *Hemibagrus*, etc.), walking catfish (*Clarius*) and snakehead (*Channa*). This trap is observed in Kut Chiang Mi and Na Kae villages of the upper and the middle Lam Se Bai.

Vertical cylinder trap

Flexibility trap (Loub yued, Eroa): Flexibility trap is a variation of net trap. The frame is made by steel or stainless and covered by twisted polyethylene net, so that foldable and easy to carry to fisheries ground. When spread it, the size is about 2-7 m long and 0.5 m high with four to ten segments. The fish entrances are alternately opened near the bottom of each segment. Every kinds of fishes can be collected without any bait. Flexibility trap is sold about 22-26 US$ (700-800 bahts) in the market and it introduced around 2005 in Na Kae village of the middle Lam Se Bai. "Eroa" is the northeastern dialect.

Flexibility trap

Lying trap (Suang, Son): Lying trap is a simple indigenous fishing gear to collect snakehead (*Channa* spp.), walking catfish (*Clarius* spp.) and other small fishes around paddy fields. It is laid down on the waterwey between embankment of paddy fields and canals. The size is 1.2 m long and 0.15 in diameter. The trap is weaved by splitted bamboo. Local inhabitants traditionally use lying trap, but it is currently hardly found in the Lam Se Bai basin. "Suang" is the northeastern dialect and "son" is the standard Thai language.

Lying trap

Snake head trap (Chud): This is an indigenous fishing trap to catch snakehead around paddy fields. The trap is placed on the small waterway beside of embankment and tie it up with the sticks. Once enter the trap, the fish can not go out because it is as same size as the trap. Local inhabitants have weaved the trap by means of ivy of climber plant, *Toxocarpus spirei* (Family Asclepiadaceae) until 20-30 years ago, but it is currently hardly found in the Lam Se Bai basin. They prefer another fishing gear because fish dies shortly in the trap. "Chut" is northeastern dialect to express the climber plant.

Snakehead trap

Eel trap (Lun): A specialized fishing gear to catch swamp eel (*Monopterus albus*) in muddy waterways. The trap is made by cylindrical bamboo which consists of 4-5 segments and about 0.8-1.2 m long. Small holes are drilled for fish breath. Nowadays, it is made by polyvinyl chloride (PVC) pipe. Earth worm, smashed or fermented snail, crab and fish meat are put into the base of the trap to attract swamp eels. The trap is horizontally or diagonally put in the shallow waterways, usually not deeper than knee level. Eel trap is observed at the lower Lam Se Bai and the Chi river. "Lun" is the standard Thai language.

Eel trap

Botia trap (Bang): The structure is similar to eel trap, but this trap is specialized to catch cobitid fishes, *Botia* spp. The trap is made by cylindrical bamboo which consists of 4-5 segments and about 1.2 m long and 80 mm in diameter. The trap is laid down on the shallow waters about 0.1-0.3 m deep. Bait is unnecessary because the trap provide only fish habitat. We found this trap at Nong Kin Phen village where is located near the junction of the Lam Se Bai and the Mun river.

Botia trap

Box trap (Jun pla chon, Jun pla kor): A small woody box trap to catch snakehead fish (*Channa striata*) and walking catfish (*Clarius* spp.) utilizing the fish behavior to hide in narrow gap. The box size is about 45 x 30 x 20 cm. The trap is laid on the mud of extremely shallow water without any bait. Fishes come into the box for mating and breeding. Although snakehead fish is commonly cultured in Thailand, capture fishing is still performed in the northeastern Thailand. Box trap is found in Kut Chang Mi village of the upper Lam Se Bai.

Box trap

Catfish trap (Loub pla duk): A small box trap to catch walking catfish (*Clarius* spp.) and other fishes inhabiting the shallow waters of rivers, channels, reservoirs, ponds and paddy fields. The box size is about 0.3-0.5 m and the frame is made by metallic wire covered with fine wire mesh or twisted polyethylene fiber. The fish entrance is opened vertically or horizontally on both sides. Catfish trap is found in the upper and the middle Lam Se Bai.

Catfish trap

Fish trap (Loub pla, Loub duk pla): Semi-cylindrical shaped trap to catch fishes, crabs and other aquatic organisms around river sides. The size is about 0.8-1.0 m long 0.5 m in height and the frame is made of rattan and covered with twisted fiber net. Chopped fishes are placed in the trap to attract fishes. The pathway is sometimes dug to guide fishes and crabs toward the entrance of the trap. This trap is commonly used in the coastal areas throughout the Thailand, but it is is rarely seen in the Lam Se Bai basin.

Fish trap

Frog trap (Ngaeb, Duk kob): A bag shaped small fishing trap to catch frogs (*Rana* spp.) in the paddy fields and swamps. The trap is weaved by only splitted bamboo and about 20-30 cm in size with the oval shaped entrance. Insect, fermented fish and crabs are usually used to attract frog at midnight. Frog trap is frequently observed throughout the Lam Se Bai basin. "Ngaeb" is the northeastern dialect and "duk kob" is the general term for it.

Frog trap

Bush shelter trap, Bush pile trap (Yoa, Klum): Bush shelter trap or bush pile trap is an indigenous fishing method in riparian swamps and is categorized as a kind of fish attractant device. A bundle of tree branches are combined each other to make bush basket and submerged it in the shallow water. Wooden poles stand to connect the basket to prevent it drifting. The basket provides the preferred habitats and breeding sites for fishes inhabiting in the bottom layer; for example, snakehead (*Channa striata*), sheatfish (*Micronema* spp.), catfishes and small cyprinid carps. Every a few days, fishermen collect these fishes by mean of gill net (No. 1) or handy surrounding net (No. 3) by surrounding the bush basket. This fishing is collaboratively operated by several fishermen. Bush shelter trap fishing is found in Na Kae village of the middle Lam Se Bai. "Yoa" is the northeastern dialect and "klum" is the central or the standard Thai language.

Bush shelter trap, Bush pile trap

Bush shelter, Branch shelter (Klum, Ban pla): Local inhabitants preserve fishes in the reservoirs and irrigation canals beside of their own paddy fields. They put a bundle of tree branches and bamboo piles in the waters to provide shelter and habitat for fishes. Branches are also useful as a landmark to protect their fishes from disturbance by other villagers. Whenever they collect fishes, they remove branches from the waters, and then they catch fishes by means of net. Although the structure is same as the former one (bush shelter trap), bush shelter is a kind of fish aquaculture activities. Bush shelter is widely observed throughout the Lam Se Bai basin, but this method is

prohibited at the public waters. Both "klum" and "ban pla" are the standard Thai language. This method is also found in the paddy fields and ponds in Laos and other Asian countries (Akimichi *et al.*, 2008).

Bush shelter, Branch shelter

Hook and line (Bed): Hook and line are popular fishing gears observed in everywhere in Thailand. In general, it consists of a main line, sometimes a few branch lines, with hook(s) and sinker. Monofilament nylon or cotton yarn are used for lines. The rod is made from natural materials such as bamboo and rattan, but glass fiber rod is presently used. Big hook of about 30 mm is used to catch the big catfish (*Pangasius larnaudi*, *P. sutchi* and *P. siamensis*), knifefish (*Notopterus notopterus*, *Chitala ornata*), sheatfish (*Wallago attu*) and so on. Crab, shell, warm, fruit (for *Pangasius*), chicken, rice bran and some other edible materials are attached to hook as fish bait. During the rainy season, big catfish, *Pangasius larnaudi*, comes to eat the fruit of "waa tree (*Syzygium*)" in the floodplain of Na Kae village. "Bed" is the standard Thai language.

Hook and line

Pitch hook (Bed tong, Bed pak): Several bamboo rods are set on muddy embankment of the shallow waters of reservoirs, ponds, channels and paddy fields, to catch mystus (*Hemibagrus*), walking catfish (*Clarius*), snakehead (*Channa*), and other small fishes.

Pitch hook

Pitch hook is consists of bamboo rod, string and hook. The rod is about 80 cm in length. Worm, crushed snail, grasshopper, frog, crab and small fish are used as fish bait. The hooks are usually kept overnight and collect them in the next morning. Pitch hook is frequently observed in the Na Kae village as well as other Lam Se Bai basin and is sold about 0.1 US$ (3 bahts) per pole in the market. "Bed tong" is the standard Thai language and "bed pak" is the northeastern dialect.

Long line (Bed roa): Fishermen sometimes make a long line to hanging a series of branch lines with hooks and suspended it in the rivers, reservoirs and floodplains. A series of hooks are set at about 1-2 m intervals. Crab, shell, worm, fruit, chicken and some other edible materials are used as bait. Long line is sometimes observed in the middle and the lower Lam Se Bai basin. "Bed rao" is the standard Thai language.

Long line

Plunge basket, Cover pot (Sum): Plunge basket or cover pot is a simple fishing gear to catch fishes in quite shallow water mainly at night. The shape is like a conical basket and is made of splitted bamboo with the surroundings forked toward the bottom. The size of the basket is about 40-50 cm in height, 40 cm in bottom diameter and 10-15 cm in upper diameter. Termites, Ants or other organic matters are placed on the water as fish bait. Fisherman holds the top of the gear to wait without moving for a while. When fish come to snap the bait, fisherman plunged vertically the basket. The market price of plunge basket is 5.4-9.6 US$ (170-300 bahts). In Myanmar, the larger plunge basket "Inlay basket" is operated with fishing boat (SEAFDEC 2006). "Sum" is the standard Thai language.

Plunge basket, Cover pot

50. Fish scaring boat (Rua phee loak, Long pla): Fish scaring boat is a very unique indigenous fishing gear. Large rectangular white board of about 3 m x 0.7 m is installed beside of small fishing boat by means of steel frames and fish net of about 3 m x 0.8 m is installed on another side of the same boat. In the nighttime of new moon, fishermen move slowly the boat without engine in the rivers and swamps. When fishes come up against the white board they surprise and spontaneously jump up from the water into the boat. Main target fishes are sheatfishes (*Kryptopterus limpok* and *K. cryptopterus*) and mud carp (*Henicorhynchus siamensis*). This fishing appeared to be operated until 15-20 years ago around the tributaries of the Mekong river basin, but it is currently difficult to find it. We found only one boat on February 2012 at the coast of Tha Khon Mai Yung village where is located near the junction of the Chi river and the Mun river. More detailed explanation of this fishing is presented by Punswarn (2005) and Tapkorn (2010). "Rua phee loak" is the standard Thai language which means "ghost scaring boat". "Long pla" is the northeastern dialect.

Fish scaring boat

Spear (Chamouk): Spear is a simple fishing gear consisting of long shaft, usually of wood or bamboo, with

a pointed head, the tip of which is divided into several to nine. Fisherman use it at nighttime to capture snakehead (*Channa* spp.), catfish (*Clarius* spp.) and frogs (*Rana* spp.). When he light up on the water, fishes come to the surface, so that he spear the fishes. Spear is observed throughout the Lam Se Bai basin, but nowadays it becomes not popular because fishes decrease and the operation is not efficient.

Spear

Harpoon (Chamouk deaw, Chanak, Som sud pla): A harpoon is a long spear-like fishing gear to catch comparatively large fishes. It is also consisting of a shaft, usually of wood or bamboo, with one pointed steel tip. The shaft is longer than the spear and the total length is about 5-6 m.

Harpoon

Scoop net

Scoop net (Sawing, Takpra): Scoop net "sawing" is a simple fishing tool to scoop small fishes, crabs, shrimps and other aquatic animals in shallow ponds, reservoirs, rivers, swamps and paddy fields. The size is 0.2-0.5 m in diameter and mesh size varies from 3-10 mm according to the purpose. The frame is made by rattan, steel or plastic, and the net is made of nylon, polyethylene fiber and twisted cotton yarn. It is sold 1-3 US$ (30-100 bahts) in the market and the fishing tackle store. "Sawing" is the standard Thai language and "takpra" is the northeastern dialect.

Long pole scoop net (Sawoak): "Sawoak" is a kind of scoop net with a long shaft. It is also a supplemental fishing tool to collect and carry fishes and other aquatic organisms. "Sawoak" is the standard Thai language.

Long pole scoop net

Scoop basket (Chanang, Takpra): Scoop basket "chanang" is an indigenous fishing tool to collect small fishes and other aquatic organisms in shallow waters. The frame is made by rattan and the basket is made of splitted bamboo or twisted polyethylene fibers. Local inhabitants have used it about 20-30 years age, but it is currently hardly found in the Lam Se Bai basin. "Chanang" is the standard Thai language and "takpra" is the northeastern dialect.

Scoop basket

Water scoop (Phoang, Kaso): Water scoop "Phoang" or "Kaso" is an indigenous tool to scoop water in paddy fields and canals, but it is also used for collecting small aquatic organisms. It is made of bamboo pole and splitted bamboo. Local inhabitants have used it about 20-30 years age, but it is currently not used in the Lam Se Bai basin. "Phoang" is the standard Thai language and "kaso" is the northeastern dialect.

Water scoop

Other collecting tools: For local inhabitants, handy collecting is a basic fishing activity to collect shell, crab, worm and freshwater algae. They sometimes use shovel and scoop for digging the soil.

Container

Container (Khong): Fishermen keep and carry fishes into bamboo container, "khong". There are a lot of kinds of containers according to the shape and the purpose. They are made of locally available materials, splitted bamboo, ivy, rattan, and twined fiber net and string, but nowadays, plastic and polystyrol containers are also used. "Khong" is the standard Thai language.

Container

Basket (Takra, Kata, Kung pla): Basket type container is used for routine works of local inhabitants. It is made of coconut shell, splitted bamboo and rattan. Water container ("khong tak nam") is made of coconut shell and be available to carry living fishes with water. Nowadays, plastic bucket becomes more popular. "Takra" and "Kung pla" are the standard Thai language and "kata" is the northeastern dialect.

Basket

Fish bag (Sai pla, Kung pla): Fish bag is a supplemental tool to keep and carry the fishes. Local inhabitants prefer polyethylene net bag because it is cheep and stout.

Fish bag

Fish cage, Crawl, Fish preserve (Sai pla, Kung pla): Fishermen use fish cage or crawl to keep fishes for a short period. The cage is made of metal or bamboo frame, which is covered by polyethylene net. Polystyrol float, plastic float or polyethylene terephthalate (PET) bottle are used for floating the cage.

Fish cage, Crawl, Fish preserve

Aquaculture cage (Krachung, Kung pla, Leang pla): Fish aquaculture are very popular around the Lam Se Bai basin, in which cage aquaculture systems are found in the rivers, ponds and reservoirs. Tilapia (*Oreochromis niloticus*), tapian (improved strain of tilapia), catfish (*Pangasianodon hypophthalmus*) and some other freshwater fishes are cultured into the cage mainly in the rainy season.

Aquaculture cage

Acknowledgements: We are grateful to inhabitants and fishermen who gave us a lot of valuable knowledge about the traditional fishing and village lives. This study was supported by the Global Environment Research Fund (D-0902) of the Ministry of the Environment, Japan. This study project was implemented in collaboration with several Japanese and Thailand research institutes; that is, National Research Institute of Aquaculture, Japan (NRIA), Forestry and Forest Products Research Institute, Japan (FFPRI), Faculty of Fisheries of Kasetsart University, Thailand (KU) and the Chulalongkorn University, Thailand (CU), the members to whom our gratitude is due.

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J. Agrofor. Environ. 11 (1 & 2): 15-19, 2017 ISSN 1995-6983

Comparative eco-resource utilization studies in Asia: Poor management in rich areas and wise use in poor resource areas

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Abstract: Tropical rain forests in South East Asia were once the richest forests in the world. But because of the loggings from 1950's, almost all the good resources were lost now by excessive exploitation without any consideration of sustainability. On the other hand, in the poor resource areas like high mountain areas in Eurasian continent or small remote islands in the Pacific, well-thought sustainable utilization of eco-resources were conducted for generations. There are several attempts showing ideal eco-resource utilization in temperate and tropical areas by the people's own efforts. In the eastern part of Yunnan, China, the villagers started eco cultural village to conserve their historical village and surrounding fine landscapes. These projects were established by the villager's bottom up wish to keep their own culture and resources. In the Kitayama forest areas in Kyoto, Japan, foresters were producing beautiful timbers by planting high density with high pruning techniques. Slow growing of taper trees and artificial waving on the surface of polished pillars were originated from there. Ladakh in northern India, people using small amount of wood resources with careful management. Developed areas need to learn from indigenous people's way of simple life.
Key words: Eco-resources, tropical rain forests, sustainability, indigenous people

Introduction

South East Asia (SEAsia) and East Asia are the highest population areas in the world. Drastic change of environmental issues were seen in these areas after 1950's. Tropical rain forests in SEAsia were once best forest resource area in the world before 2nd World War. But after independence of tropical countries, the heavy logging operation caused the big loss of biodiversity in the area. On the other hand there are still maintaining sustainable way of life in the remote parts of the region where the simple and harmonious life together with nature is still continued. In the former case, destruction of the rich area was so quick to lose most of the good forest sites within 50 years. Whereas in the latter case, poor resources are well maintained for their simple way of life. With increasing population, we need to consider how to live in the future. Since the high economic growth could not be expected any more, we have to learn from indigenous people's way of living.

In this paper, I am focusing on the comparative studies of two extreme areas; rich tropical areas and poor resources area in the remote region, and think over important role of harbor cities in between them.

Materials and Methods

I have been working in South East Asian tropical rain forests in more than 40 years starting from 1965. Field works have been carried out in Indonesia, Malaysia, Brunei, Philippines to measure biomass in the forests and continuous measurement of thousands of trees in the survey plots. Part of the results were summarized in my book (Yamada, 1998). During that time, I have also conducted interview of the surrounding people in the sites and found the rich tropical timber resources have gone within 20 years (Yamada, 1995).

After tropical areas, I have started my works in other type of the areas such as high mountains and small islands where amount of resources are very poor. There I found sustainable way of resource management in Ladakh in India, and Aru in Indonesia, Kitayama in Japan and Yunnan in China (Yamada, 2000; 2006).

Based on those long term research experience, I come to think over the concept of eco-resources. Eco- resources is a fundamental resource management concept as shown in Fig. 1. Eco-resource is divided into three parts, one is global environmental issues and second is a biodiversity. Third one is more important related to the human behavior, named human eco resources, which is divided into three parts, i.e. one is life resources, second is eco cultural resource, and the third is spiritual world. The most important is the central eco cultural resources. Most of the natural scientists who have been working in the global environmental issues have been concentrating only in the natural phenomena for many years. Only recently inter-disciplinary studies of natural science, humanities and social sciences, are conducted. I have been working in many areas based on this concept for more than 20 years. All the materials come from my fieldwork.

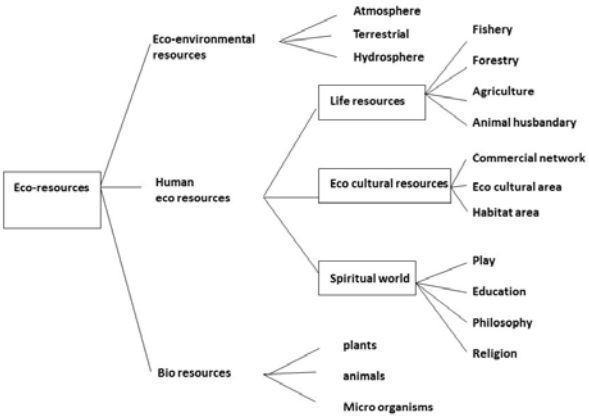

Figure 1. Diagram of eco-resources concept

Results and Discussion

Disturbance of tropical rain forest in Southeast Asia after 1950: My first step on SEAsia tropical rainforest was 1965 to make botanical collection trip to Thailand, Cambodia and Malaysia. At that time the destruction of the tropical rain forest was not so severe. In 1969 to 1970, I spent one year in Bogor National Biological Institute where I had my Ph.D. field work in Mt Pangrango, Java, Udjun Kulon, Sumatra and East Kalimantan, the logging has just started in East Kalimantan but not so severe. But

after 1970's, the logging of tropical rain forest in Indonesia and Malaysia has spread with enormous speed especially in Borneo island which is the center of rich resources of tropical timber. For cutting Dipterocarp tress, of which straight bole is suitable to make rotary veneer, most of the areas has been designated as a concession and production sharing system was engaged. The logs were mostly sent to Japan and used for building construction. Japan, at that time, was a babble economic era so the demand of the logs were never stopped. In the late 1980's, almost all the good forest sites were logged over and Indonesia declared ban on log export. But for inner saw mill, the loggings were continued and they saw in their own sawmill and export to outside **(**Fig. 2). Because of the heavy logging of the area, export amount of log from this area is reduced now and many major logging companies seeks their resources out of the area. In 1988, huge scale of fire occurred in the Borneo island which spread all over neighboring countries and 40,000 people are suffered at one time. This fire is still occurring even nowadays.

Figure 2. Mega rice project sites of peat swamp forests, Central Kalimantan, Indonesia

Tropical rain forests of SEAsia were the richest bio resources in the world. Fine Dipterocarp trees are really the treasure of the area. Since it was abundant in natural condition, people never think sustainability. Even there are some sustainable management system like Malayan system was considered but not widely adopted. In 1969, wherever we go, we could see beautiful rain forest, but now, it is very difficult to find such good forests. We lost one of the most important biological heritage within 50 years.

Eco-resource management of poor resource areas in the frontier area of Eurasian Continent and remote island in the Pacific

(I) Ladakh-Shangrila in the sky: After tropical SEAia, I shifted my interest to remote area in Eurasian continent. Here I show the field work in Ladakh, which is located in the mountain top of India surrounded by Pakistan and China. Before Ladakh, I have been working in China from 1990's and Yunnan and Tibet were my major field. To compare the situation of Tibet, I have visited Ladakh to see their life and eco-resources. Ladakh is a high mountain areas beyond Himalaya and very dry area with little rainfall. Cold temperature and dry land means scarcity of bio resources. Almost no original forest, except for Juniper. People are planting willow trees and poplar trees along the river. They use their farm land to plant willow seedling with dense spacing and the stems were cut so that coppices are to be grown. These coppices are collected to use for ceiling. For the bigger branches, which are used for roof supporter are trimmed every year. At the first year, they cut down smaller size branches so that remaining branch became much bigger. And the second year, they cut bigger branches. For the bigger stem which is used for the pole of the house is also taken from the bigger coppices of popular trees. For this purpose, main stem is cut and multi stems are produced. Water is only available near the stream. To maintain good water resources, one family who are succeeded from their ancestors are responsible to maintain of water canal and plant willow trees along the stream (Fig. 3).

Figure 3. Cutting willow tree branches in Nyemo, Ladakh

Before entering the Ladakh, I thought it is difficult to get wood materials for daily life. But because of their scarcity of natural resources they tame their minor resources as much as possible. They are all belong to Tibetan Buddists. Their temple- Gompa is always located in the deep valley. When we reached the temple, we found many trees are planted along the stream and all well maintained. The location of Gompa is splendid. Most of them are built on the hill top or slope which is surrounded by the gigantic snow mountains. People are very religious and doing very humble and sustainable way of life.

(II) Aru islands: Aru islands are located south of New Guinea Island, Indonesia, which is the second largest island in the world but Aru are the gathering of small island which means the area producing resources are not big enough if it is not well maintained.

People of Aru have their own regulation called *sasi*-which is widely known in Wallacea region (Akimichi, 1995). In the case of Aru, almost all the eco-resources are setting *sasi*, e.g. birds of paradise are not allowed to hunt all year round. This is the most valuable resources in the island so they have strict regulation for stop hunting every 2 months. Similar moratorium is set for bird's nest. Bird's nest here is easy to approach which can be found under the ceiling of lime stone cave just behind the mangrove. The ownership is clear and people watch the outside invaders during *Sasi* period, Sea cucumber, hawksbill turtle, Sago and even planted coconuts and Rambutan have their own *sasi*.

Sasi is a unique autonomous regulation aiming not too much disturbance of the natural life cycle. The real sustainable way of living is found in these small islands. To maintain small amount of eco-resources in small land, this kind of self regulation seems most favorable for the small community. No outside regulation can be adopted in the area (Fig. 4).

Figure 4. Sago palm in Aru

This similar attitude to minor resources are also found in indigenous people life in SEAsia. For instance, Penan, who are originally hunting gatherers in the tropical rain forest of Borneo island, have similar sustainable way of life. Although most of the Penan people are now settle down in one place, there are still some people who are moving around the forests. Since they have to move one place to another, their daily materials are limited and no odd things are around. Only very necessary things they carry and found animals and plants needed in their life.

Their knowledge about the forest are deep and wide. Almost all the plants and animals are known to use as a medicines, foods, materials for daily life. They never cut too many trees, not take too much fruits and animals. They know their consumption capacity. Since there are no ice box in the forest, they have to consume what they get in the day. This is quite natural attitude because if they don't think sustainability, they can not survive.

Once they get some products, they share equally in the community. There are many important habitat of them, in which they name the place with their memory and keeping their position always in the forest. Their way of wandering in the forest is not arbitrary. They know where their necessary products are found and remember the place with naming the spot. These life style is found even in the traditional forestry area in Japan.

(III) Kitayama forestry: Kitayama forestry area is located at the north western part of Kyoto city, central Japan. This area is covered by the medium size mountains between 500-1,000m level and people here once engaged in the shifting cultivation on the steep slopes. In the primary forests in the area, Sugi (*Cryptomeria japonica*) is the main species which grow mixed in the broad leaved trees. From the stump of the big size Sugi more than 1m diameter, coppice shoots can grow. First stage of forestry practice are started to cut these coppice pole for construction in 600 years ago (Fig. 5). With the demand of Kyoto city house construction, most of the houses are built by using Kitayama forestry timbers. People in Kitayama area create new technology to polish the pole by natural sand which is only found in nearby Bodainotoki waterfall area. Sand is granite origin and when it is used to polish the surface of timber, grain of the sand became smashed and fine brilliant surface of the pillar is appeared. To grow straight good pole, they plant seedling densely as much as 10,000 tree per ha. Frequent thinnings and prunings are carried out until harvesting time for 40 years. The land is not fertile but rocky soil which is good for slow growth and non-nods good timbers are harvested.

Figure 5. Old stump of Kitayama Forestry Area

I have been visiting this area frequently with many guests from abroad. They are surprised to see the beautiful landscape on the steep slopes on both sides of Kiyotaki river. German forester was very much impressed to see in such a steep slope plantation. In Germany, they can never plant trees in such steep slope condition. Final products peel off bark, sand polished and wrapped carefully and sent to Kyoto.

Many carpenters have personal connection with producers and come to buy with their own taste and built beautiful wooden house called Sukiya zukuri. There sometimes found waving on the surface of timber, which is called Shibo. Eighty years ago, people create new technology to make this waving on the surface of timber wiring small pegs on surface of timber 2 years before cutting. This make artificial waving and be sold 4-5 times higher price than ordinary timbers. Most of the plantation is now using cuttings from the mother trees. The mother trees are well treated and make special shape as called Dai sugi. This special shape tree is used for Japanese garden in many temples and private gardens in Kyoto. Small sized timber called Taruki is also obtained from the stump and specially used for tea room.

Kitayama was once the richest forestry area in Japan as well as in the world. Their way of forestry practice is always based on their daily observation and practices in the forests. Their deep insight to the forest and create new technology make unique artificial forestry area. Whenever I visited Kitayama forestry area, I found very thoughtful local practical knowledge are succeeded in this area for generation to generation.

(IV) Eco cultural village in Yunnan: Yunnan is located at the south western part of China bordering to continental southeast Asia. There are nearly 50 minority groups living

in the mountains and in the basins. They have own autonomous policy and keeping good tradition. One 600 year historical village in eastern part of Yunnan, the villagers are starting to build eco-cultural village by themselves. They built small museum in the village where they stored traditional tools and historical documents and their techniques are also practiced in here so that young generation can learn from their ancestors. Songs and music are practiced in this museum.

This village is surrounded by the lime stone hills and lakes which are used for eco tourism inviting whole Yunnan population. The important point of this project is that all the design is done by villagers headed by young village head and some supporters from local government and university professors. It is very unique in China because most of the local activities have been mostly decided from the central government top down policy. This eco-cultural village project is purely bottom up basis and they have their own regulations not to damage traditional landscape so that they don't use modern material for the renovation of the houses and roads. Surrounding sacred places are maintained not changed and total area is declared as a nature and cultural resources. This project is not touristic purpose but many people are visiting now from all over China and villagers entertain outsiders by traditional local food. Fig. 6 shows their activities.

Figure 6. Eco cultural village in Yunnan

There are now five similar eco-cultural villages in Yunnan. To learn from this village, visitors from other provinces often visited. This is an ideal case in China to put important value on their own local history.

Forest and human society

As mentioned above, there are two opposite faces. One is rapid decrease of rich forest areas without any sustainable management and the other is bottom up traditional way of management by indigenous people. In the case of tropical rain forest, not so much destruction occurred before the Second World War. But after many tropical countries made independence from western developed countries, they need financial basis for development. Timber is the most easy and abundant resources for the tropical country to get income from natural forest. The speed of loggings were very quick starting from the Philippines in 1950's and come to Indonesia and Malaysia in 1960's onward. Within 20 years, most of the good sites were logged over and logging operation invade deeper and deeper in the forests. There are many conflicts between logging companies and Penan people in the 1980's up until now. This trend is not confined in SEAsia, but in Amazon in South America and even in Crayquot in Canada the logging of primary forest create conflicts between loggers and indigenous people. Many international NGO and NPO groups supported indigenous people and some of the area was kept untouched because of the strong international movement, especially at the occasion of UNCED in Rio de Janeiro in 1992. But after that, logging are still continuing in many places and the rate of the destruction of the world forests are still very high.

Whenever I spent among the indigenous people, I feel very comfortable with their simple way of life, They take only what they need for the day. Not with high demand like the people in the modern society, they are happy and satisfied and share their products equally in the community. Human relations are so good so that each people help each other when it is needed. The human relations in the modern world is quite different from them. We are losing many important basic culture and mentally important factors with losing forest. Forest is a simple world where we can see many organisms are living together. For millions years, trees, insects, animals and micro organism are survived comfortably. There are many good relationship by which we learn how the living organisms behave each other. Biodiversity conservation means to keep the variety of these millions creatures interaction.

The attitude of indigenous people is good example for the future of human life. We have to keep more simple life. The term "sustainability" is the word made by modern people but reality is existed in the life of indigenous people. Their daily life itself is the sustainable life. The summary of forest and human society are as follows:.

Forest and human society

- Era of warning from Indigenous people's life to present world
- Limit of modern technology and Information
- How to survive from environmental degradation and resource shortage
- Satisfaction under limitation and sustainable utilization
- Equilibrium of spirit and materials
- Effort to rehabilitate ecosystem – diversification and development non disturbing utilization
- Strengthen close relation between city and forests.
- Reconsideration of present civilization from the point of simple life

Role of Harbor cities in East and SEAsian

From wide scale view, there exists three part in the eastern part of Eurasian continent. One is mountainous Tibetan and Himalayan regions in the north western part of eastern Eurasian continent. And the second is the tropical lowland in maritime world which include big islands like Borneo, Sumatra, New Guinea, and so on. In between them, there are many harbor cities like Hong Kong, Singapore, Kobe, Yokohama, Bangkok, Tenjin, Shanghai and so on. This area has a long trade history of the eco resources from

both areas. Especially after the opening of the market in China, 1980, huge amount of material flow are concentrating in this region. Tropical timbers export are now decreasing more than half compared to 1970-80', but most of them are sent to China. To satisfy 13 billion people's demand, world trade are focusing to China. But with high speed development, many obstacles such as severe pollution, rich and poor gaps, mental and spiritual disorders, are frequently occurred in the area.

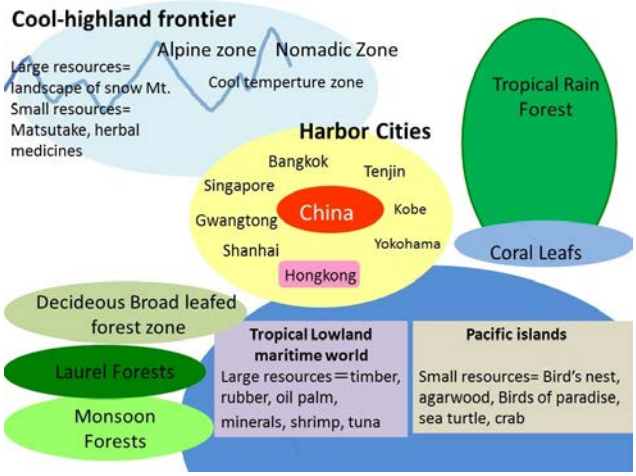

Figure 7. Diagram of two opposite sites and harbor cities in between

This trend was once seen in Japan in 1960's at the time of bubble economical conditions. Almost all the timber resources were imported from SEAsia to Japan. Production of industries are so high without any regulation to protect from pollution. As a result, all the rivers and cities were polluted badly and many critical deceases were occurred in Minamata, Agano, Yokkaichi and so on. But in 1970, onward, Japanese policy for protecting environmental pollution become very strict so that all the sources of pollution were checked and new technology were created which lead good result for many aspects.

We should not repeat Japanese failure in the future. Since East and Southeast Asia are very near each other, most of the pollutants are easily spread all over the areas. Careful treatment which is basically found in the primitive areas where the simple and sustainable way of life are existing is needed. We have to learn from indigenous people. Their way of life is a good warning to the times.

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J. Agrofor. Environ. 11 (1 & 2): 21-24, 2017 ISSN 1995-6983

Interim survey report on livelihood transition studies in Pursat province, Cambodia

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Abstract: Rural livelihoods around the world drive and reflect changing environmental regimes and political economic transformations. In Southeast Asia where rural small holders are densely habited, livelihood systems of these populations are mostly based on the operational interface between the environment and society. Presently, rural livelihoods in Southeast Asia are rapidly changing basically from subsistence-oriented to market-oriented system, and shifting from on-farm to off-farm sectors to generate more cash income. This study is to figure out how the benefit of market- and industry-driven economic development spread into rural people and how to mitigate its adverse impacts on rural society. The study was conducted in Pursat Province, Cambodia as it is a rich diversity in the biophysical environment, and comparatively, it has a rather short development history. The results present the diversity of livelihood in the whole province which is reasonably classified into seven zones-lake zone, coastal zone, coastal low land zone, low land zone, low land upland complex zone, mountain zone and upland zone. In addition, the density of population in the area has been changing back and forth within the seven zones. However, it is not very clear what socio-demographic characteristics differentiate groups of household, so the detail finding will be identified in the next survey.
Key words: Livelihood transition, diversity in livelihood option, further studies.

Introduction

Rural livelihoods around the world drive and reflect changing environmental regimes and political economic transformations. In Southeast Asia where rural small holders are densely habited, livelihood systems of these populations are mostly based on the operational interface between the environment and society. The livelihood systems play substantial roles in achieving natural resources-dependent sustainable development when self-ordered livelihood systems with the supports of good governance well function, and this mechanism does not properly works once either self-ordered livelihood systems or good governance collapse (Saphangthong and Kono, 2010). Rural livelihoods in Southeast Asia are rapidly changing basically from subsistence-oriented to market-oriented system. Subsistence crop production has been replacing by commercial crops and labor allocation of rural household is shifting from the on-farm to off-farm sectors to generate more cash income.

This study is a part of a broader study of livelihood transition in rural Southeast Asia. Broader study focuses livelihood transition in rural Southeast Asia, aiming at examining the form, process and consequences of livelihood transition particularly from the viewpoints of natural resource management and social dynamism.

One of the remarkable points of this study is the scope of livelihood transition study. So far, many studies focus on changes in livelihood and examine the opportunities and risks that rural household are facing (Kono *et al*., 2009, Doppler *et al*., 2006). These studies figure out how the benefits of market- and industry-driven economic development spread into rural people and how to mitigate its adverse impacts on rural society. It is also true, however, that the on-going changes of rural societies in Southeast Asia are much more holistic and are not limited to the economic activities only. Social domain is widened from local-based to global-based and people's career development depends more on public institutions rather than family network. These social changes are undoubtedly closely connected to changes in economic activities and affect the form, process and consequences of livelihood transition. The livelihood transition in this study covers the overall changes in livelihood systems.

Materials and Methods

Study area: After the preliminary surveys in December 2010 and March 2011, Pursat Province/river basin of the Cambodia has been selected as the study region. Pursat Province is located from 11.84° to 13.01° north latitude and from 102.70° to 104.40° east longitude from Tonle Sap Lake from the Northeast to boarder of Thailand towards the Southwest (Fig. 1). The provincial head quarter Pursat city is connected to the Capital of the country Phnom Penh through national highway no. 5 and southern end of the Veal Veng town and Thai border can be accessed with the newly constructed earthen road. The main reason for selecting this area is because of appropriateness of the area as a good representative of rural Southeast Asia for the study of rural livelihood transition. The area is very suitable for carrying a livelihood transition study because of the two main reasons. First, the area has a rich diversity in the biophysical environment including the lakeside coastal area, lowland and mountainous area. Second, comparatively, it has a rather short development history. The population density of the area at the beginning of the 20th century was less than 20 persons/km2 (Delvert, 1958). Most of the area was covered with dense forest until the 1960s. Currently various types of livelihood activities are going on and rapidly changing within very short period. So for all these reasons this area is very suitable for exploring the whole process of development depending on the memory of people in addition to utilizing the archival documents.

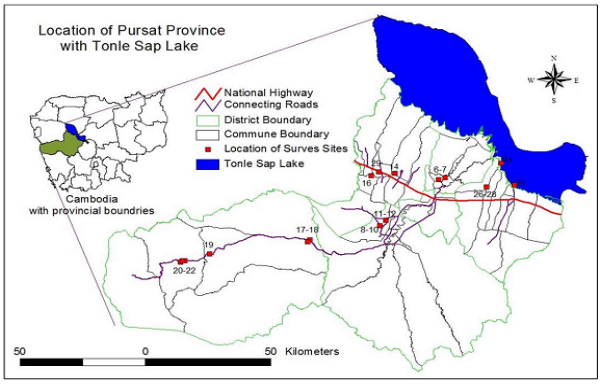

Fig. 1. Location map of Pursat Province, Cambodia

Results and Discussion

General description of the Province: Population is concentrated in the coastal and lowland zones reflecting longer settlement history and better access to market and road network. The family size is smaller in the upland and mountainous zones. This probably suggests the dominance of newly married family. The percentage of house with tile roof is higher in the coastal lowland, lowland and lowland/upland complex zones, while the percentage of house with zinc roof is higher in the coastal and upland zones. Tenant and small-scale rice-grower is rather popular in Krakor district where farmer cum fishermen has been a main livelihood system. Aquaculture is popular in the lake and coastal zones. The elementary and junior high school attendance is 80% or more, but some communes in the lake, coastal, upland and mountain zones shows lower attendance. The percentage of women who delivered a baby by service of midwife shows a big difference among the communes, less than 10% in some and more than 80% in others, and comparatively high in the coastal lowland and lowland zones and low in the lake, coastal, upland and mountain zones. The percentage of children aged 9 to 12 months who have received full immunization is more than 80% at almost all communes. Work away is most popular in the coastal lowland zone, followed by the coastal and lowland zones. In-migration is popular in the upland and mountain zones, while out-migration is popular in the lake, coastal, coastal lowland zones. The rainy season rice yields do not significantly different between zones. They are higher along the mainstream of the Pursat River, around 3 t/ha, and lower in Krakor district, around 1.5 t/ha. Dry season rice growing is practiced only in the coastal lowland and lowland zones. The spatial difference of dry season rice yield is similar to that of wet season rice yield.

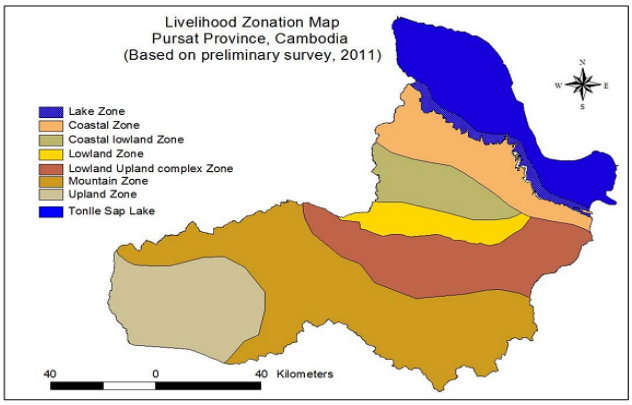

Fig. 2. Draft livelihood zoning map of Purast province, Cambodia based of preliminary survey

Diversity in livelihood options/strategies: Based on the spatial differences in biophysical setup from Tonle Sap Lake to the mountain region, different farming and fishing activities with various ways of livelihood patterns can be seen. Currently adopted livelihood strategies also have gone through various ways of transformation in the past. Thus from this point of view, whole province can be roughly divided into seven zones (Fig. 2) based on the available natural resources, their accessibilities, currently adopted livelihood strategies and the process of transformation to date. Brief descriptions of each zone are as follows.

Lake zone: This is completely water-based zone. This zone is located on Lake (Fig. 3). Fishermen are living in this zone on floating houses. Major livelihood activities are fishery, aquaculture and fish processing. Fish catch has decreased during the last 10 years. Fish processing including prahok, p'ok and dry fish (trey ngiet) making declined more sharply because of selling fresh fish become popular. The people in this zone seem very mobile, both inward and outward migration. Some rich households have recently shifted their livelihood to land-based systems.

Fig. 3. Lake zone

Coastal zone: This zone is immediate next to the pure water based zone (Fig. 4). People in this zone generally live on land but their livelihood activities are based on both land and water systems. People in this zone adopted farmer cum fishermen livelihood though they gradually have been shifted their livelihood more on farm-based. Rice productivity is still low and fish catch is declining. Working away at Thailand and Phnom Penh emerged as the popular job for the young generation.

Fig. 4. Coastal zone

Fig. 5. Coastal lowland zone

Coastal lowland zone (intensive and commercialized rice zone): This zone is immediate next to the coastal zone (Fig. 5). This is pure land based system. This zone has the longest history of human settlement in this province. Most of the areas of this zone located near to the Pursat market center. The main livelihood activities have been rice growing supplemented by fishery and sugar palm collection in the past, which have been replaced by livestock and aquaculture recently. Rice yield increased owing to the spread of new rice cultivars and chemical

fertilizer, and rice growing has been commercialized in recent days. Working away at Thailand and Phnom Penh as wedged laborer is also popular in this zone.

Lowland zone: This zone is similar to the zone number three in many regards. However, in regards to the development history this zone has relatively shorter history than to the zone number three. Beside the development history, another difference is that people living in this zone did not generallydo fishing activities in the past too. This zone was reclaimed in the 1950s and 60s. Rice growing has been the predominant livelihood activities since then. Owing to large farm size, there has been surplus production. The innovation of rice trading network in the 2000s further commercialized rice growing in this zone (Fig. 6). They introduced marketable cultivars and farm machinery. Working away at Thailand and Phnom Penh emerged as the popular job for the young generation.

Fig. 6. Lowland zone in Cambodia

Lowland upland complex zone: This zone is a transitional zone between lowland and upland system (Fig. 7). Both lowland production systems such as rice growing and upland activities such as maize production can be found in this zone of transition. People in this zone depend both on lowland and upland farming for their livelihood strategies. Upland farming shows drastic changes. It was small-scale and subsistence until the 1980s. In 1990s when the trading channels were established, they expanded upland field and started to grow commercial crops such as groundnut and watermelon. Recently cassava growing has been in practiced because of an animal feed factory was established and a big market of cassava emerged. A few young people go to work at Thailand and Phnom Penh.

Fig. 7. Lowland upland complex zone in Cambodia

Upland zone: Rural livelihood in this zone area based on pure upland farming system. This zone is on the way of reclamation (Fig. 8). Inward migration mostly from densely populated areas such as Kampong Cham and Kampong Chhnang provinces continues. The major crops are maize, soybean and mungbean.

Fig. 8. Upland zone in Cambodia

Mountain zone: This zone is located on the high altitude areas of the province towards the mountainous region (Fig. 9). This zone is very scarcely populated. Both indigenous and recently migrants people from other part of the province as well and other part of the country are living here. However, survey team was able to meet recent migrants only. People's livelihood in this zone mainly depends on forest products and very recently started to grow upland crops such as upland rice, maize and some varieties of beans.

Fig. 9. Mountain zone in Cambodia

Process of livelihood transition: The process of livelihood transition also has a wide range of diversity.

In the lake and coastal zones, decline in fish resource and strict regulations of fishing activities such as restriction of many fishing gears seem to be the major driver of livelihood transition. Many fishermen seem to be started to shift their livelihood from lake-based to land-based systems.

In the coastal lowland and lowland zones, the major driver of livelihood transition is the innovation of rice trading network. Rice market shifted from domestic to international markets. This triggered changes not only in rice trading but also in rice production. Rice traders pay more attention to the quality of rice. Farmers widely adopted rice cultivars that are high-valued at the international market. In order to meet the demands and criteria of international market, the whole steps of rice production, processing and trading are on the way of innovation.

In the lowland/upland complex and upland zones, the major driver is upland crop production for agro-industry. Their crop choice totally depends on the market requirement. For the example of cassava cultivation, the operation of the cassava processing factory of the Pheapimex Company in Krakor district since the end of 2010 determined the trend in the research area (the Pheapimex Company got a land concession with the central government in November 2003 that covers more than 315,000 hectares of land in six districts of Pursat and Kampong Chhnang provinces).

Another prevailing driver is work away at Thailand and Phnom Penh. It is more popular in the coastal lowland and

lowland zones, which have the best transportation condition.

Social dynamism: Based on the changing biophysical condition of each zone, socioeconomic conditions such as household assets, farm family incomes of people are changing from zone to zone. Nevertheless as discussed above livelihood systems have been changing throughout the province. This suggests besides the changing environmental regimes and political economic transformations there might be underlying social dynamism shared by wider areas behind the ongoing livelihood transition.

It is also interesting that, though there seems to be substantial differences in household income, particularly in terms of cash income, between zones and households, the dissemination of education services in the study area does not reflect these differences. The proportion of pupil go to junior high school is over 70% except some communes in the lake and mountain zones, though the proportion of receiving a service of midwife for delivery is significantly higher in the coastal lowland, lowland and lowland/upland complex zones.

Research topics for further studies (Potential for further studies): Environmental and economic transformations in turn affect resources (land, water, fish) management regimes and decision-makers. In particular, changing environmental regimes on the one hand, and political economic transformations on the other have affect the rural livelihoods across a region or country. Rural smallholding households are often the focus of development and conservation intervention; because their responses to variable biophysical and socioeconomic contexts drive resource use and management, and therefore future strategies of local development and landscape change. Many other transformations accelerate the incorporation of rural smallholders into global economies, as both producers of goods and commodities, and as labor. As this intensified incorporation also occurs in Pursat Province of Cambodia smallholders can be expected to adjust their in-place livelihood strategies.

This preliminary survey indicates that livelihood strategies in the Pursat Province have changed a lot over the period, there are increasing proportions of households pursuing two divergent adjustment paths: one of withdrawal of the fishing business and one of agricultural intensification and commercialization. However it is not very clear what socio-demographic characteristics differentiate the groups of household's following distinct livelihood strategies. Additionally this preliminary findings point to the possibility of simultaneous land change, reduction of fish catch situation and infrastructure development are some of the drivers that attracts and/or forced the smallholders to adjust in different ways to their intensified incorporation into global economies.

Potential research questions for further research

- What types of households are adjusting their livelihood systems and what extend?
- How are households adjusting their livelihood agricultural (farming/fishing) strategies in this globalizing frontier?
- What socio-demographic characteristics differentiate the groups of household's following distinct livelihood strategies?
- Is this adjustment unfolding uniformly or along different trajectories?
- And if the latter is the case, can it be distinguished among households moving in different directions?
- Finally, how these changes may affect the local landscape in the region?

Some specific research topics of this study:

1) Innovation in rainfed rice production and trading
- Shift of rice market from domestic to international and its consequences
- Technology and productivity of rainfed rice growing
- Impacts on farmers' livelihood

2) Challenges and potentials of livelihood development
- Zoning with two spatial direction one from urban center towards the Lake and other from urban center towards the mountain
- Development process of production/farming and fishing system
- Challenges and future potential to be developed in the future with different types oflivelihood option

3) Transformation of trading goods and network in the region
- Traditional trading route/ means of productions: paddy rice, crops, timber and
- NTFP etc.
- rading network of basic goods for living: salt, prahok, oil and so on.
- Creation of the linkage with outsiders.

The results present the diversity of livelihood in the whole province which is reasonably classified into seven zones-lake zone, coastal zone, coastal lowland zone, lowland zone, lowland upland complex zone, mountain zone and upland zone. In addition, the density of population in the area has been changing inward and outward within the seven zones. However, it is not very clear what socio-demographic characteristics differentiate groups of household, so the detail finding will be identified in the next survey.

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J. Agrofor. Environ. 11 (1 & 2): 25-29, 2017 ISSN 1995-6983

Hydrological environment and Boro rice cultivation in Bangladesh and Assam

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Abstract: In Bangladesh and Assam, rice is the main agricultural products for local farmers situated as both the countries in the Brahmaputra basin. Rice is traditionally cultivated in the rainy season, but frequent floods and droughts make its production unstable. Bangladesh successfully increased the cultivated area of Boro rice in the dry season which enables stable rice production. On the contrary, in Assam, the introduction of Boro rice is marginal, and they still depend on rainfed rice for their subsistence. This study aims to investigate the mechanism of the recent disparity of rice cropping system between Bangladesh and Assam by using the high-resolution surface water data. The results show that topography or soil condition may be responsible for the difference of surface water variation in post-flood season and Boro rice introduction in the dry season between the two regions. Boro rice area showed remarkable increase in some districts of Bangladesh where surface water was available after flood, but the amount of surface water in post flood season and the extent of increased Boro rice area in February did not match well. The water supply technology for Boro rice cultivation should be investigated to reveal the mechanism of Boro rice variation in the flood years.
Key words: Bangladesh, Assam, Boro rice, Irrigation, Flood, Surface water.

Introduction

The Brahmaputra is one of the biggest river during Monsoon in Asia with the river basin of 573,000 km^2 where total 80 million people live in. Its main stream and tributaries flow across four countries; China, Bhutan, India and Bangladesh, but most of the population live in the lower part of the basin; 31 million in India and 47 million in Bangladesh (Rahman and Varis, 2009). In those regions, low-lying floodplain topography and humid monsoon climate provide the suitable condition for rice cultivation which is the main occupation of rural people.

Rice is traditionally cultivated during the rainy season as summer monsoon rainfall and river water inundation bring water supply for its cultivation. In Bangladesh, Aman rice is the main crop which is transplanted in August and harvested in December (Johnson, 1982). Also in Assam, Sali rice is grown in the same season (Bhagabati *et al*., 2001). Those rice are usually grown under the rain-fed condition without artificial irrigation, but the problem is they are vulnerable to floods in summer season (Mowla, 1972; Brammer, 1990). In the lower part of the Brahmaputra basin, both rainwater floods and river water floods frequently submerge paddy fields under water, and severe floods cause huge damage on rice production once in several years (Hofer and Messerli, 2006). Not only floods, but also drought can affect rice cultivation during rainy season when monsoon activity becomes weak.

In Bangladesh, however, the traditional rice cropping system shows drastic change in recent years (Fig. 1a); while the cultivated area of Aman rice remains same level, the cultivation area of Boro rice has rapidly increased during the last three decades. Boro rice is grown during December to May in the dry season with the constant supply of irrigation water. The influence of drought and flood on Boro rice is less. Now the double cropping of Aman rice in the rainy season and Boro rice in the dry season is common in Bangladesh, which makes annual rice production more stable than before.

Though the cultivated area of Boro rice increases year by year in Bangladesh, it rapidly increased in 1988, 1998 and 2007 when severe floods occurred in the whole country. The cultivated area of Boro rice can usually increase with the introduction of irrigation systems such as power pump and tube well. In the severe flood years, especially the cultivated area of high yielding varieties (HYVs) of Boro rice increased much, and its area exceeded more than the irrigated area for Boro rice (Fig. 1b). These statistics indicates that the local farmers cultivated HYV Boro rice in new fields without introducing any irrigation facilities.

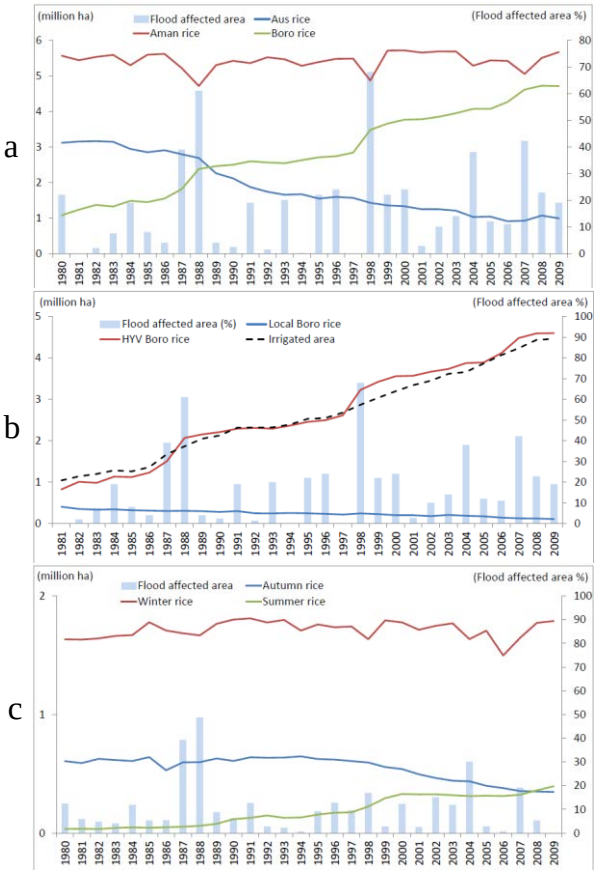

Fig. 1. Rice cultivated area (million hectare) and flood affected area (%) (a) in Bangladesh, (b) Boro rice area with irrigated area, (c) in Assam.

Why they could successfully increase the cultivated area of Boro rice without irrigation facilities after the severe flood? A hypothesis can be proposed for explaining the

fact. The cultivation of Boro rice normally starts from December when the natural water is little available in fields. Water supply is the most limiting factor for Boro rice cultivation in the dry season. In flood years, residual water may be available in fields even after flood season, and farmers can increase the cultivated area of Boro rice by utilizing the residual water (Asada *et al*., 2005; Asada, 2012).

In Assam, on the other hand, the change of rice cropping system is relatively slow (Fig. 1c). Even in the severe flood years of 1988, 2004 and 2007, the introduction of Boro rice is very marginal. As the result, they still depend on Sali rice in the rainy season for most of the total production, though the cultivated area of Boro rice is slowly increasing. Unlike with Bangladesh, rice cropping system in Assam is still traditional with unstable annual production highly affected by flood and drought. Why they cannot increase the cultivated area of Boro rice drastically like Bangladesh? The second hypothesis is that residual water is not available in Assam after flood season and they must wait for irrigation facilities from government for increasing Boro rice area.

The information of surface water variation will be the key for solving the above questions in the lower Brahmaputra basin. This study aims to investigate the mechanism of the recent changes of rice cropping system in Bangladesh and Assam by using the high-resolution surface water data.

Materials and Methods

Land surface water coverage (LSWC) data was used in this study to investigate the seasonal and inter-annual variation of surface water. The daily LSWC was calculated in 10 km-grid resolution by combining the information from satellite-based sensors of MODIS and AMSR-E for the period from 2003 to 2010 (Takeuchi and Gonzalez, 2009). LSWC data is shown in percentage of water coverage in each grid. The grid-level data was converted into country (state)-level and district-level data to compare with statistics of rice cultivation. The number of districts used in this study is 20 in Bangladesh (excluding 3 districts in Chittagong Hill Tract in southeastern part of the country) and 23 in Assam.

The data of flood affected area in Bangladesh and Assam was obtained from Bangladesh Water Development Board (BWDB), Central Water Commission (CWC) in India, respectively. The data indicates the annual flood affected area in percentages of the total geographical area. An area to be included in the flood affected area needs only to be flooded once during the considered monsoon season (Chowdhury, 2003). It was used to define the severe flood years in each region.

The daily rainfall data was obtained from APHRODITE's Water Resources project (Asian Precipitation – Highly-Resolved Observational Data Integration towards Evaluation of Water Resources project, http://www.chikyu.ac.jp/precip/index.html). The 0.25-degree grid-level rainfall data sets were calculated primarily with data obtained from a rain-gauge observation network (Yatagai, 2012). The grid data was converted into district-level data.

The data of cultivated area and irrigated area of Aman, Sali and Boro rice in district level in Bangladesh and Assam were also collected from Agricultural Department of each government.

Results and Discussion

Hydrological condition of Bangladesh and Assam by LSWC data

LSWC data shows annual and seasonal variation of surface water, but the data contains all kinds of surface water including river channels, lakes, paddy fields and artificial canals. Therefore, anomaly value from 8-year average was considered for the analysis (Fig. 2). In severe flood years of 2004 and 2007, positive anomaly of LSWC is seen during rainy season both in Bangladesh and Assam. Negative anomaly of LSWC is seen in 2006 and 2009, which means drought condition due to weak monsoon activities.

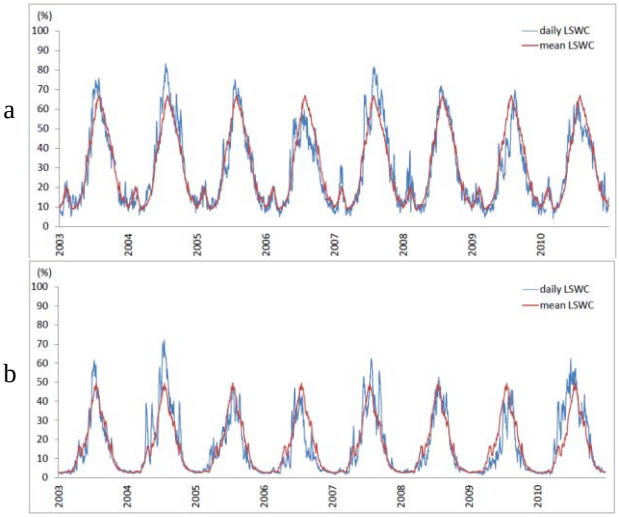

Fig. 2. Variation of LSWC in (a) Bangladesh and (b) Assam

When the positive anomaly of LSWC from June to September is compared with the flood affected area data for the period of 2003-2010, they show a good positive correlation (Fig. 3). In the years when positive anomaly is more, the flood affected area is more, and vice versa. Therefore, the positive anomaly of LSWC is used as a flood index in this study.

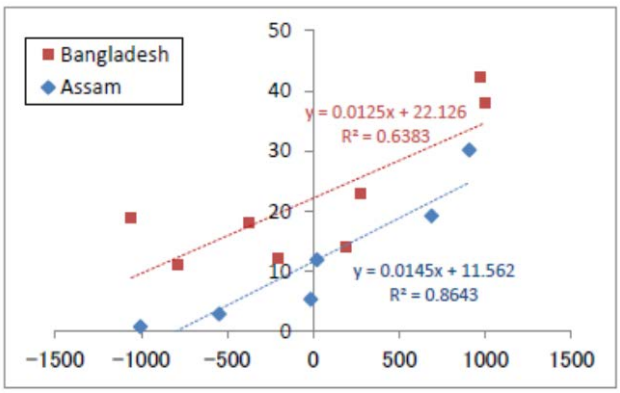

Fig. 3. LSWC anomaly during June-September (X) and Flood affected area (Y) for 2003-20010 in Bangladesh and Assam

Both in Bangladesh and Assam, LSWC value becomes larger in summer season and smaller in winter, which shows the seasonal variation of surface water associated with seasonal monsoon cycle. However, LSWC variation in Bangladesh shows a small peak in February, when neither rainfall nor river water inundation occur. The seasonal variation of mean LSWC in February seems to be related with Boro rice transplantation (Fig. 4). In many districts of Bangladesh, more LSWC increase from January to February means more Boro rice transplanted by supplying irrigation water. In the coastal districts and northeastern districts, however, LSWC in February does not correspond to Boro rice area. In Khulna and Patuakhali of the coastal districts, LSWC is high in February, but the Boro rice area is little. LSWC in the districts may not indicate the irrigation water for Boro cultivation, but the brackish water intrusion used for shrimp cultivation (Deb, 1998). In Sylhet and Kishoreganj of the northeastern Bangladesh, the surface water stays longer after flood season due to depressing topographical structure in the region (Johnson, 1982). Boro rice transplantation starts in the decreasing water condition from January to February without additional supply of irrigation water.

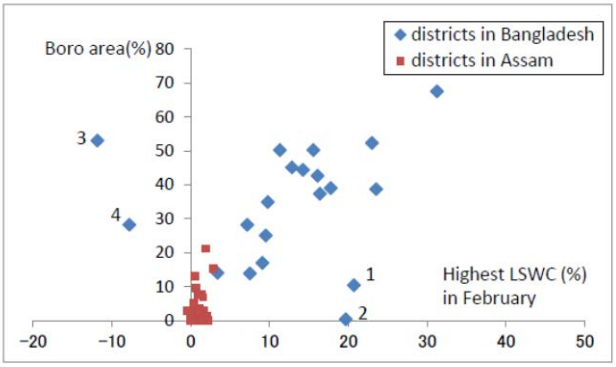

Fig. 4. The change of mean LSWC from value on 1st January to highest value in February (X) and Boro area (Y) in districts in Bangladesh and Assam. 1 Khulna district, 2 Patuakhali district, 3 Kishoreganj district, 4 Sylhet district

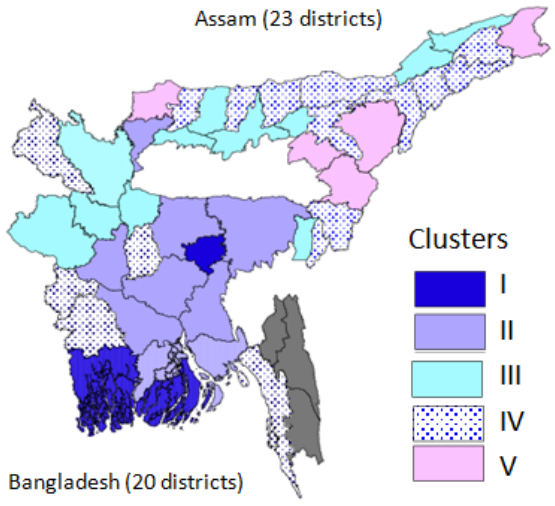

Fig. 5. Regional classifications by cluster analysis of mean LSWC variation

Regional classification by LSWC variation: Although Bangladesh and Assam are situated in the lower Brahmaputra floodplain and partly in the Ganges delta, the hydrological condition largely differs by district. Then, a regional classification was examined by cluster analysis for the 8-year mean LSWC variation of total 43 districts (Fig. 5). As the result, districts in Bangladesh and Assam were classified into 5 regions (Fig. 6).

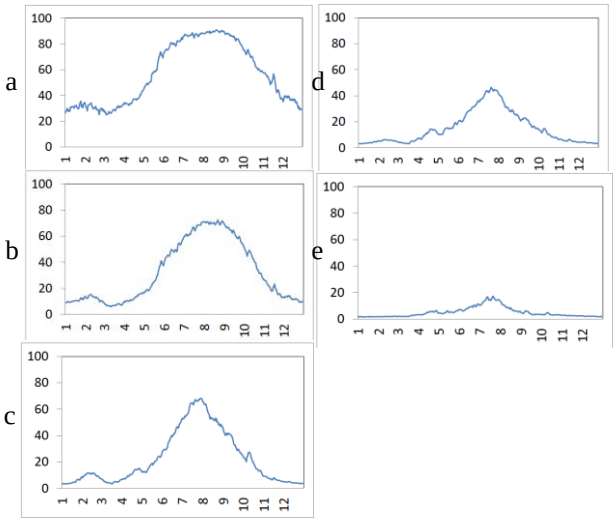

Fig. 6. Mean LSWC variation (%) in (a) Cluster I, (b) Cluster II, (c) Cluster III, (d) Cluster IV, (e) Cluster V.

Coastal districts and northeastern district in Bangladesh belong to Cluster I where the LSWC is higher throughout the year. LSWC exceeds 90 % in August and September, and does not fall below 20 % even in December. Districts in eastern Bangladesh belong to Cluster II with higher LSWC from June to October. Northwestern districts in Bangladesh and some districts in Assam belong to Cluster III with higher LSWC during shorter period in July and August. Districts in western Bangladesh and central-eastern Assam belong to Cluster IV where the LSWC is relatively less except for July. Hilly districts and the most upstream district in Assam belong to Cluster V where LSWC is little throughout the year. From the downstream (Cluster I) to the upstream (Cluster V) of the lower Brahmaputra basin, the surface water coverage gradually decreases which suggests the effect of basin scale topography.

Table 1. Characteristics of five clusters

Cluster	Annual rainfall	Irrigation (%) for		Boro rice area (%)
		Aman rice	Boro rice	
I	2126.0	0.8	147.4	21.7
II	2117.3	7.6	79.4	31.2
III	2122.5	4.8	30.1	20.8
IV	2019.8	10.4	31.3	12.7
V	2003.9	15.0	15.8	1.3

Characteristics of five clusters were summarized in Table 1. The variation of annual rainfall among five clusters is little, therefore, it can be said that the difference of mean LSWC variation by clusters is mainly attributed to topography or soil condition rather than rainfall amount. LSWC in rainy season is higher in Cluster I, II and III, but the irrigation for Aman rice cultivation during the season is little. This means LSWC in rainy season does not show the artificial water, but the natural water including river

inundation and rain water. On the contrary, irrigation for Boro rice cultivation in dry season is higher in Cluster I, II, III and IV which indicates artificial water contributes to LSWC in the dry season, especially in February.

LSWC variation and Boro rice area in flood years

The influence of surface water on Boro rice area was examined in each cluster region. The accumulated anomaly of LSWC during June to September was used as the flood index, and top two flood years were selected for composite analysis in each district from 2003 to 2009.

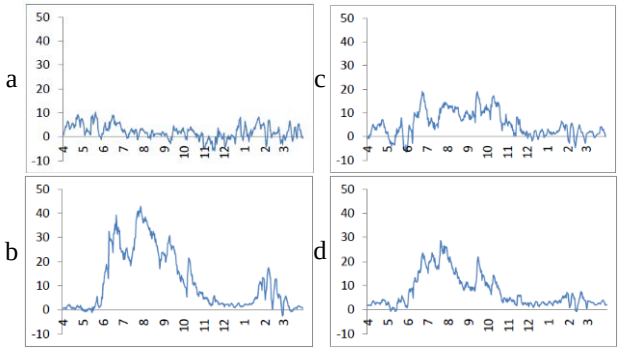

Fig. 7. LSWC anomaly (%) in flood years in Bangladesh. (a) Cluster I, (b) Cluster II, (c) Cluster III, (d) Cluster IV.

First, districts in Bangladesh were examined (Fig. 7). In districts of Cluster I, LSWC anomaly in flood years is positive during both flood season (June-September) and post flood season (October-January), but the anomaly is not large. In districts of Cluster II, III and IV, positive anomaly of LSWC continues in post flood season, which indicates the residual water after flood. Not only in districts of wetter region (Cluster II), but also in districts of drier region (Cluster IV), surface water is available after severe floods in Bangladesh. However, districts with more LSWC anomaly in post flood season do not always show the increase of Boro rice area (Fig. 9a). Districts with moderate amount of accumulated LSWC anomaly (500-700 %) show remarkable increase of Boro rice area, while districts with little LSWC anomaly (< 500 %) and too much LSWC (> 700 %) show little increase of Boro rice area.

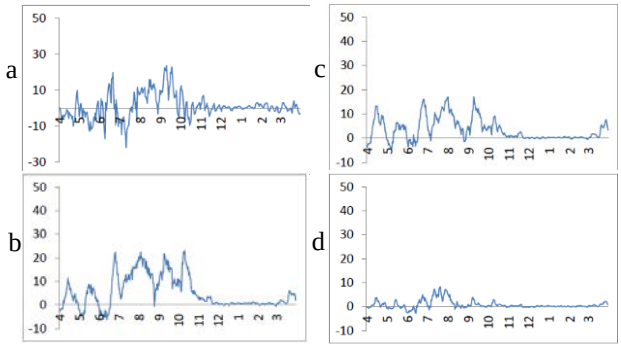

Fig. 8. LSWC anomaly (%) in flood years in Assam. (a) Cluster II, (b) Cluster III, (c) Cluster IV, (d) Cluster V.

Among districts with moderate amount of surface water during post flood season, increase of Boro rice area is not stable, but vary by district (Fig. 9a). Some districts show remarkable increase of Boro rice area, but other districts show only small increase of Boro rice even though the available amount of surface water is almost same. This suggests that the amount of surface water is not the only determining factor for increasing Boro rice area. The water utilizing technology and other social factors are also necessary for increasing Boro rice area in flood years.

In Assam, LSWC anomaly during June to September is relatively less, and it sometimes becomes negative even in flood years (Fig. 8). The positive anomaly of LSWC during post flood season is seen in districts of Cluster III and IV though the anomaly is much less than that in same clusters in Bangladesh. Therefore it can be considered that surface water cannot stay longer even in flood years due to topography or soil condition, and farmers cannot use flood water for Boro rice cultivation. In Assam, the accumulated anomaly of LSWC during post flood season is much less than that of Bangladesh (Fig. 9b), and the increase or decrease of Boro rice area is not related with the amount of surface water.

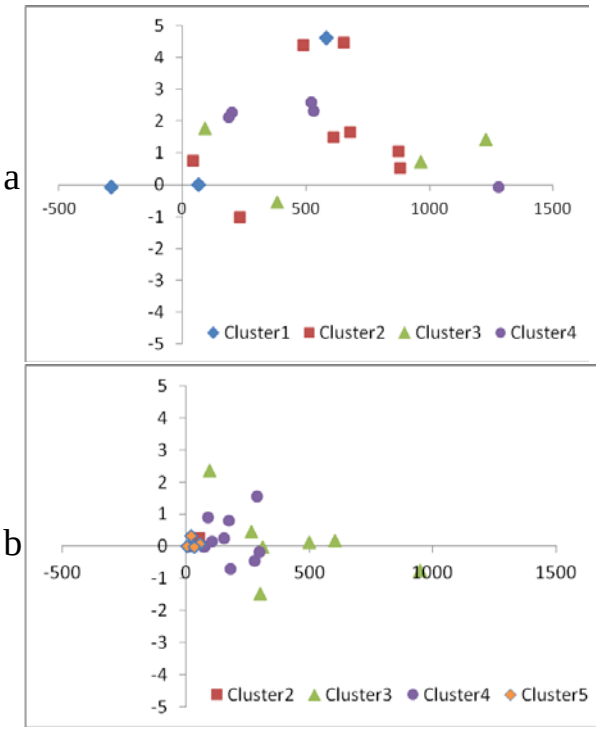

Fig. 9. LSWC anomaly during October to January (%) and Boro rice area change (%) in flood years. (a) Bangladesh, (b) Assam.

Conclusion

This study investigated the role of surface water for increasing Boro rice area in flood years in Bangladesh and Assam of the lower Brahmaputra basin by using the satellite-based LSWC data. The hypothesis that farmers used surface water after severe floods for Boro rice cultivation without introducing artificial irrigation was partly true in Bangladesh. In fact, the LSWC anomaly continued positive in October and November of post flood season, which could be utilized for increasing Boro rice area in some districts of Bangladesh. However, LSWC anomaly became almost zero in December and January and it again became positive in February of Boro rice transplanting season. This means farmers did not use residual water of floods directly for Boro rice cultivation as surface water almost disappears before transplanting

season of Boro rice. Therefore, the water supplying technology for Boro rice cultivation should be investigated more to reveal the link between surface water during post flood season and field water used for Boro rice cultivation in February. The surface water is little seen after floods in many districts of Assam, and the Boro rice did not show significant increase like Bangladesh. Macro scale topography of the basin or soil condition may be responsible for the difference of surface water variation between Bangladesh and Assam.

Acknowledgment: Part of this research was supported by the Grant-in-Aid for JSPS Fellows (No.11J00348).

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J. Agrofor. Environ. 11 (1 & 2): 31-33, 2017 ISSN 1995-6983

Causes and impact of migration from Brekha village, Trashigang Bhutan

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Abstract: In recent years the high rate of rural to urban migration has become alarming with the influx of more and more people into urban areas from the rural areas. Against such a backdrop this paper studied and examined various causes of out-migration from the Brekha village to the urban areas which resulted to rapid deterioration of agricultural production in the village leading to the escalation of per unit cost of agricultural production. A survey on 55 households comprising of 100 people was conducted in Brekha village. This study revealed that from every household at least one or two members migrated to other parts of the country. Some of the family members have moved permanently to other places while some others were seasonal.The causes of out-migration from the village were for education, better standard of living, and drudgery of village lives. The outcome of rural migration was influx of employment seekers in the urban job market and unavailability of enough work forces in the village thereby hampering pace of economic development in the village. Therefore, the Royal Government of Bhutan has recommended some measures to curb the migration from rural areas by providing better facilities and trainings for the people living in the rural areas.
Key words: Impact, migration, Brekha village, Bhutan.

Introduction

Brekha is one of the villages under Khaling Gewog in Eastern Bhutan under Trashigang district. The economy of the village is predominantly agriculture oriented. The village has a primary school which is connected with a farm road. However, the village lacks health facilities as even for a minor sickness. People have to go either to Riserboo Hospital which is 22 kms away or to BHU in Tsangpo village which is around 10 kms away. "Migration is a spatial mobility of people by changing usual place of residence to a well-defined destination" (National Statistics Bureau, 2008). Migrant are defined as persons who were enumerated in a place different from the place where they were born. In other words, migration is the movement of people from one geographical location to another, involving permanent or temporary settlement. Migration is one of the three components of population change. Any change in the volume and flow of migration will change the size, growth, and other characteristics of the population both in sending and receiving areas. Migration within a country does not affect the total size of the population and growth rate but it affects regional and sub-regional population and growth rate within the country. The migrants remit to the area of origin from the area of destination and thus at times migration have positive impacts to their area of origin. (Stark, 1991). This in a way leads to the diversification of income. Nevertheless, migration also has negative impacts as well. This case study was conductedto examine the cause and impact of migration in Brekha Village, under Khaling Gewog, Eastern Bhutan with the objectives (i) to find out the cause of rural migration and its impact and (ii) to give recommendations to check the rate of migration from rural areas.

Materials and Methods

A case study design was adopted in this research where Brekha village was chosen as a case. The data for this study were mainly collected through a survey from 55 households and 100 respondents. The respondents were selected randomly. The primary data for the study were gathered through administering a structured questionnaire. Existing literature were used for secondary data. Besides a few statistical tools was used in this study.

Results and Discussion

Gender Distribution of Respondents: Survey data revealed that 80% of the respondents were females while only 20% were males. This shows that the majority of the migrant from the village were the male folks and those that remain in the village were the females.

The study found out that most of the migrants were of below 45 years of age. Those who have come back to the village to carry out the ancestral agricultural practices were the elderly and the aged ones. This indicates that propensity to migrate was higher among the young and energetic people (Fig. 1).

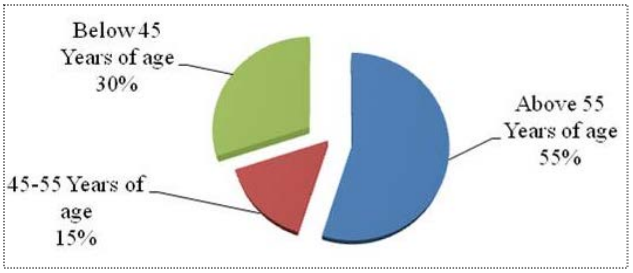

Fig. 1. Age distribution of respondents

Findings from the study also indicate that 75% of the respondents have never attended any form of education, 20 % have attended non formal education programme and about 5 % of the respondents have attended at least primary education (Fig. 2).

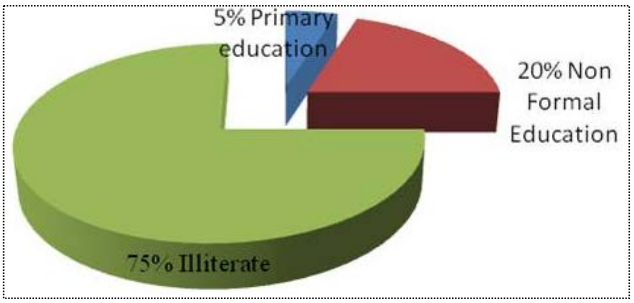

Fig. 2. Educational qualifications of respondents

This shows that with the level of education, the inclination to return back in the village was declining and the urge to migrate to other areas was increasing. Gregg *et al*. (2000), confirmed that people with higher levels of education, and those working in managerial, professional and semi-

professional, were much more likely to migrate among regions than other occupational groups.

Causes of Rural-Urban migration: The major causes of rural-urban migration were identified as; search for better wages, education, social stability, better technologies, and employment and business opportunities. Others were poverty, unemployment, crop failures and wildlife encroachment (Fig. 3) to agricultural lands (Fig. 4), inadequate social amenities and facilities in the rural areas such as lack of water supply through pipe line, electricity, good roads, hospitals, schools, vocational centres. The respondents mentioned that their family members migrated to the urban areas because of the following reasons:

Fig 3. Wildlife encroachment into the village

i) Unemployment in the rural areas: 70% of the respondents said that due to unavailability of employment opportunities or in other words, very limited job opportunities; there was high influx of young and productive age groups from rural areas to the urban areas. These group of people who have migrated to the urban areas were unskilled or semi-skilled and faceing difficulty in getting employed in urban areas as well, where there were demands for skilled work force only. A study stated thateducated persons seeking employment opportunities have high tendency to move because they have better access to information about job opportunities (Nidup and Lhendrup, 2009). Hence it has led to unemployment in urban areas on one hand and on the other hand the agricultural lands remained unattended back in the village. Due to large scale migration, the labour force hasreduced in the village. Most of the migrants were men but women, especially young women, also have moved to cities. As a result, villages were increasingly populated by older women, the elderly men, and children.

ii) Education: The other reason for moving out from the village to other urban places was mainly for the educational purpose. This was because there was only a community primary school in the village. Once the children complete their primary education they move out of the village to pursue their education. The study also found out that students despite the fact that they could study up to primary level in their village, they move to urban places with their relatives as they were not advantaged like their counter parts in the urban places who have access to quality education, internet facilities and other better opportunities. With the increased rate of female enrolment into schools, the female migrants were also increasing (Ministry of Agriculture, 2005).

iii) Seasonal Nature of Employment in Agriculture: Like in any rural areas of the country the nature of the occupation in the Brekha village was also seasonal. Once the crops were harvested the villagers remained unemployed for most part of the year and it made difficult for them to meet the basic necessities. So, to get rid of all those troublesome nature, people have migrated to places where they could get employed during their off season of agricultural.

Impact of Migration: The study has revealed that among the positive impacts, migration improved the standard of living in the village through the means of remittance from the migrants. It has also led to the reduction in the pressure on the limited resources that were available in the village when people moved out to the other areas.

Fig 4. Abandoned houses and agricultural lands

Nevertheless, migration also hadsome negative impact as well. Since the young and able people have tended to leave the village (Fig. 4), it has created labour shortages in the peak periods. Thereby, the labour shortage has led to under utilization of the agricultural lands and some fields which were cultivated in the past but left fallow for years together and in the mean time have been covered by Artemisia plants and other secondary growths (Fig. 5).

Fig 5. Growth of secondary forests after the agricultural farms were being left fallow

This has further led to increase in the encroachment by the wild animals like monkeys and wild boars even in the heart of the village (Fig. 3). With people moving out from the village, the density of the population has also decreased. As a result of low-density and dispersed population, the delivery of modern services has become more costly than the urban areas which are denser in nature. The other outcome of migration in the village was lack of enough children who wereof school going age. In contrast to the urban areas, like in most of the villages in Bhutan number of school going children in Brekha village

also reduced yearly. Thus, there was no scope for up gradation of the school (Fig. 6).

Fig 6. A community school amidst scattered settlement

The rate of rural-urban migration has been accelerating in an alarming rate in the recent years, and its effect has been felt in the urban areas where there was competition for the resources as well as in the rural areas in which the agricultural lands remain unattended because of lack of able and economically productive workforce. Hence, there was a need by the government to put in place some effective measures like the provision of the basic modern facilities, and provision of employment of the productive youths in the rural areas.

Recommendations: On the basis of findings of the study, the recommendations to check the rate of migration are as follows:

1. The Government should provide employment opportunities to the citizens of the rural areas, provide compensation for crop damage by the wild animals ; and encourage the school drop-outs and retired civil servants to go back to the village to carry out agricultural farming.
2. The government and its development partners should do everything in their power to create job opportunities for youths in the agricultural sector.
3. To curb the rate of migration from the villages, some growth centers should be set up in the villages rather than concentrating in the urban areas only. This will in a way or other boost up the economy of the rural people as there will be a market where the village folks would be able to sell their farm products at profitable prices.

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Climate change and its impact on health/livelihood of people's lives in coastal island of Hatiya under Noakhali district, Bangladesh

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Abstract: The study was carried out in Hatiya island and Subarnachar upzilas under Noakhali district to know the effect of climate change and its impact on health as well as livelihood of the peoplels. A pre-structures questionnaire was used to coleect data from the respondends. Focus group discusstions (FGDs) were also made. It revealed that the climate change affect seriously the living and livelihood of the coastal inhabitants. A good number of recommendations were made based on the findings of the study for mitigation and future strategin activities of the Govenment.
Key words: Climate change, livelihood, Hatiya island, Subarnachar, Noakhali district.

Introduction

Climate change is not just an environmental issue - it is also a health issue. Since a large part of Bangladesh is located just above the sea level, any rise in sea level may lead to inundation of settled low-lying areas which forcing people to relocate. In addition, intrusion of salt water may cause problems for agriculture in a much larger area.

The major health threats posed on climate migrants due to poor air quality (indoor and outdoor), inadequate safe water (arsenic contaminated and saline water), improper sanitation, untreated solid waste, agro-chemical and industrial effluents and overuse of renewable resources such as forests and fisheries.

The World Bank (2006) suggests that these environmental factors account for as much as 22 percent of the national burden of diseases in Bangladesh. The respiratory infections and disease caused by poor air quality, both indoor and urban, may contribute up to 10 percent of the total burden of disease. Diarrheal disease caused by inadequate access to safe water, lack of sanitation and poor hygiene may contribute up to 10 percent of the total burden of disease. Poor sanitation and industrial waste are becoming threats to the environment.

Policies on adaptation and mitigation need to focus on reducing people's vulnerability to climate change, supporting them by moving away from marginal areas and arranging alternative livelihoods to make them more resilient.

As such, a field research is imperative to assess the present status, challenges and coping mechanism of the local people to have a clear understanding of the present and potential vulnerabilities as well as way forward to address them adequately. The findings of the study can greatly help in policy advocacy as well as design and undertake appropriate project interventions.

Objectives of the Study:

General objectives: To examine the empirical evidence on the nature of present and possible climate-change-induced health and migration challenges and vulnerabilities of the coastal people of Bangladesh with emphasis on women and children, as well as to understand their adaptive capacity to climate threats.

Specific Objectives: The specific objectives of the study were as: (i) To compile evidence on the impact of climate change and disasters on health and migration in the coastal areas of Bangladesh, (ii) Understand people's (especially women and children's) vulnerability, their adaptive capacity and how government programmes and policy influence can improve their ability to cope with future climate change, (iii) Identifying likely patterns of health vulnerabilities, their impulses and the likely number of people who will be vulnerable to climate change induced health challenges, (iv) Identifying likely patterns of migration, their impulses and the likely number of people who will be vulnerable to climate change induced migration, (v) Assessing human insecurities caused by climate-change induced migration including impact on livelihoods and income, loss of social capital, impact on traditional coping mechanisms, impact on already marginalized groups, (vi) Identifying adaptation strategies and policies including options for non-migration, (vii) Exploring governance and institutional approaches that can support strategies to anticipate, prevent and, where necessary, manage climate-change induced health and migration challenges.

Materials and Methods

Introduction to the study areas: The study was carried out in one of the most vulnerable coastal districts of Bangladesh namely Noakhali which is frequently get victimed to different natural disasters caused by climate change. Hatiya and Subarnachar Upazilas (Sub-districts) of Noakhali district were covered in the study. Three unions from each of the Upazillas were selected as the study areas.

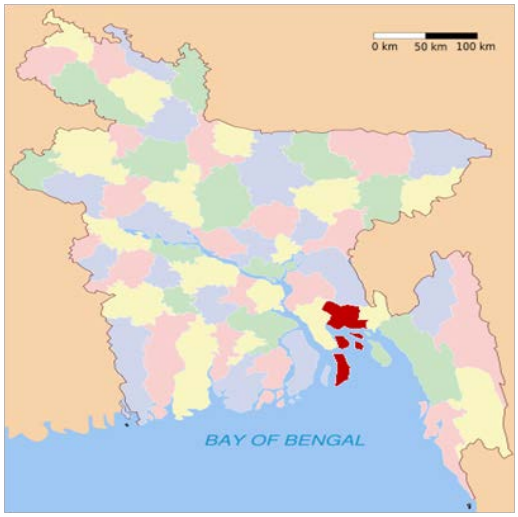

Fig. 1. Location of Noakhali District in Bangladesh Map (Red Colored)

Noakhali District: Noakhali is one of the districts of Chittagong Division in Bangladesh having a land area

of 3600.99 km^2, and is bounded by the Comilla district in the north, the Meghna estuary and the Bay of Bengal in the south, Feni and Chittagong districts in the east, and Lakshmipur is on the west (Fig. 1).

Hatiya and Subarnachar Upazillas (Sub-districts): Hatiya is an island and also an Upazila of Noakhali District having 10 Unions and 69 villages. The 1991 census of Bangladesh Bureau of Statistics (BBS, 1991) shows Hatiya has a population of 295501. Males constitute are 50.73% of the population, and females 49.27%. In this Upazila's 18+ population is 125512. Hatiya has an average literacy rate of 21% (7+ years), and the national average of 32.4% literate. It has 47970 units of household and total area 1508.23 km^2. Subarnachar is one of the new Upazillas under Noakhali District. It has 8 unions. Data were collected using pre-structured questionnaire. Focus group discussions (FGDs) were also done. Mean comparisons were done by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984) and also by Least Significant Difference (LSD) test.

Results and Discussion

The common characteristics of the coastal areas:

(i) crossed and influenced by the mighty rivers and the Bay of Bengal, (ii) many river basin char lands where flood, wave, diseases, Crop losses, safe water security etc. are problems and risk, (iii) highly vulnerable to cyclone, tidal surge and flood. Flood 2007 and cyclone SIDR 2007 caused heavy destruction and damages to people (30% of households were heavily affected and over 25,000 households comprise of over 100 thousands population lost homes, crops, movable assets, livestock and means of income), (iv) many people are landless, extreme poor and the other poor population depend for livelihood mainly on agriculture, agriculture related trading, fishing and livestock rearing. Infra-structure, safe water, sanitation, health care facilities, children schools and communication are very poor and hard to reach. There are inadequate safe shelter where the poor can go to save life and properties, (v) gender discrimination against women are high, people are fatalist, superstitious and ignorant about their rights and government essential services for them, (vi) people are largely unaware about environment, pollution, climate changes and negative impact. There is no strong feelings of people that measures could be taken to reduce vulnerability and risk of normal disasters and human induced disasters, (vii) people have inadequate knowledge, system and means to develop linkages with government and other agencies to end their sufferings and marginalization. Common people have wrong motivation from fundamentalist terrorist groups and controlled by some persons of vested interest and their supporters.

Socio-Economic Condition: The socio-economic condition of the coastal people is very poor, mostly deprived of modern amenities of life and living. Most of the respondents' average monthly income is between BDT 2,500 to 4999 while 32% have BDT 5,000 to 7,499. Of the respondents, 11% have an average monthly income of BDT 7,500 to 9,999. Only 6% respondents have an average income of BDT10, 000-14,999 and the least 2% have only more than BDT 15,000 as monthly income. The inhabitants of Subarna Char are relatively poorer than Hatiya upazilla. The FGD participants said that this income is too insufficient to manage two meals a day let alone educate the children and provide them with proper medication, comfortable living and nutritious food and recreation.

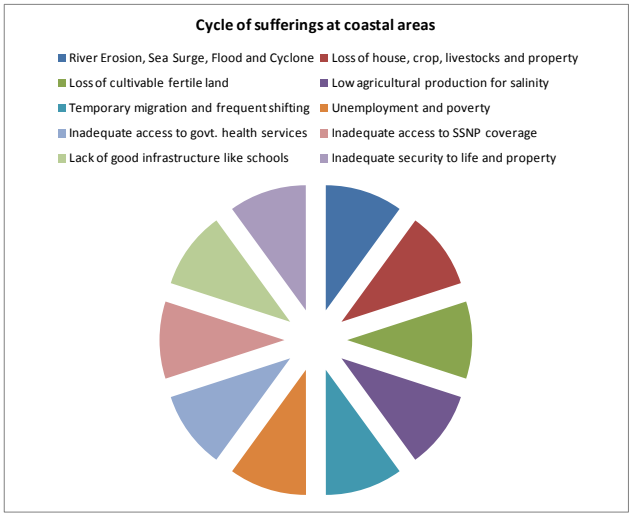

Fig. 2. Cycle of sufferings at coastal areas

The condition of the living houses is also miserable in the coastal areas since they have to repair or re-build their houses frequently as they get victimed to cyclones, floods or sea surge now and then, at least once in a year. Eighty nine percent houses are roofed with tin while 11% are roofed with straw. The floor of most of the houses (89%)is also made of earth while only 11% have floors with cement composition. The study revealed that only 44% of the respondents have their own cultivable land whereas 24% have to depend on 'Borga' (share cropping). Of the respondents 5% have some leased land while 44% could not respond in this regard meaning they have no land of their own (Fig. 2). Most of the coastal people can be categorized as the 'poorest of the poor' that have to lose huge properties almost every year due to various natural disasters triggered by the impacts of climate changes. Though a particular elite class has some sort of facilities and amenities to modern life in the district towns, the inhabitants living in the coastal belts are almost deprived of the same. They have no access to good food, quality education, proper health care facilities, shelters and recreation facilities. Every year, the coastal people are losing their cultivable lands due to river erosion, sea surge and flood. The fertile lands are turning into furrow and infertile which are losing potentialities of producing necessary crops (Fig. 2).

Frequent shifting and migration: The study shows severe adverse effects of climate changes on the life and livelihood of the people living in the coastal areas in terms of health and migration. All the respondents (100%) have mentioned that they have to shift their dwelling places due to river erosion, flood, sea surge and cyclones. It has been revealed from the study that 59% respondents on an average have mentioned that they had migrated at least once due to any of the aforesaid reasons while 20% migrated 2-3 times, 9% for 4-5 times and 11% haveto

migrate 6-10 times or more due to sternness of various disasters triggered by the adversity of climate change (Fig. 3).

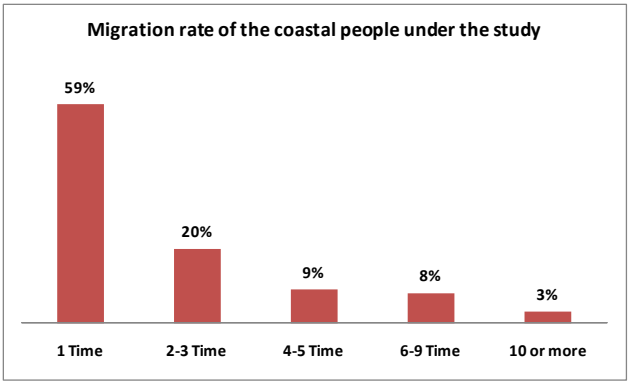

Fig. 3. Migration rate of coastal areas people

Fourteen percent respondents have mentioned that the earning members of their families have to migrate temporarily to a new place in quest of work and livelihood. The temporarily migrant family-heads usually go to the big cities including Dhaka, Chittagong, Khulna, Comilla, Noakhali and Narsingdi for seeking work. The FGD and KII respondents mentioned that frequent floods, sea surges and cyclones often cause heavy damage to the roads and communications system, human lives and live stocks, properties, houses, trees and crops. Every year the coastal people have to face the un-countable damages for which they have to lead a miserable life. Finding no other alternatives, a number of people get temporarily migrated from their own locality and go to distant places like big bustling cities, industrial and port areas in search of livelihood. Such temporary absence of the family-heads cause some problems and difficulties to their families which are as: (i) can't meet emergency needs of the family, (ii) family decision making is hampered due to the absence of the family-heads, (iii) can't support during the ailment of the family members, (iv) female members of the families especially the wives of the migrant people have to undertake much duties and responsibilities of the family members, (v) facing social harassment and insecurity, (vi) dacoits and pirates possess a threat to many migrated families, (vii) girls have to face teasing/social menace on the way to schools/destinations, (viii) lack of legal support, (ix) insecurity to the family members, loss of property and house-hold assets.

Unemployment and poverty are constant companions of the people. The FGD participants mentioned that on average the coastal people have to migrate 2 to 3 times mainly due to river erosion. People have migrated from outside of embankment to inside of the embankment. However, there are some positive sides of temporary migration which include: (i) developing communication and relationship with a new place and people, (ii) outsourcing for work and wages, (iii) gathering information and developing knowledge on different areas and work opportunities, (iv) saving the family members from adverse effect of the disasters by earning some money.

The problems and difficulties the migrants have to face are: (i) adjustment with a new place and environment, (ii) severe sufferings due to living at a very cheap cost preferably in slum or footpath, (iii) physical and mental ailment, (iv) scarcity of safe water, break up of studies and living amidst uncertainty, (v) unsecured life, (vi) lack of familial care and love in a distant place.

The FGD participants also told that the women and children have been lagging behind the process of climate change adaptation. It has been revealed from their discussion that the health risks are on the rise due to climate change. People have been experiencing new health hazards for excessive heat, cold, rain, drought, huge dust etc. Compared to health hazards and risks, the facilities of the treatment are too inadequate even to serve one fourth of the coastal people under the study. The participants mentioned that unavailability of qualified doctors and lack of modern health care facilities are the common characteristics of the government hospitals in the coastal areas. The FGD participants informed that it takes at least two hours to reach the nearest hospital by boats. Thus, the coastal people are almost deprived of health care facilities.

Health hazards: In the surveyed area, 38% respondents thought that health hazards have been increased due to adverse effects of climate change while 57% respondents have no idea of the same. Compared to other coastal regions, the respondents of Hatiya had mentioned about the health hazards more. The following health hazards have been mentioned by the respondents which are given below as per different age strata (Table 1).

Table 1. Health hazards of the respondends according to their age category

For children	Fever, Diarrhea, extreme cold, Cough, Pneumonia, Skin Diseases
Adolescent boys	Fever, Diarrhea, Catching cold, Cough, Pneumonia, Skin Diseases, Asthma, Jaundice
Adolescent girls	Fever, Diarrhea, Catching cold, Cough, Pneumonia, Skin Diseases, Asthma, Jaundice, Menstrual Problem
Pregnant Mothers	Catching cold, Cough, Asthma, Breathing Problem, Headache, skin drying, Body bulging
Lactating mothers	Delay to cure wounded area, Hemorrhage, Ache in belly area, Skin diseases
Aged people	High Blood Pressure, Diabetes, Fever, Asthma, Heart Attack, Cancer, Stroke, Skin Diseases
Old age people	High Blood Pressure, Diabetes, Fever, Asthma, Heart Attack, Cancer, Stroke, Rheumatic Fever, Paralysis.

Apart from these, the respondents also mentioned that they have been experiencing some sorts of diseases which were new to them and might be caused due to severe effect of climate change. The 'new diseases' are Jaundice (Hepatitis), Lever disease, Asthma, influenza, viral fever and other viral complexities, Diabetes, Heart Attack, Stroke, Gastric Ulcer , Cancer etc.

The FGD participants mentioned that breathing problem increased, some people are dying suddenly. These problems did not happen earlier, as well as problem of tonsil has been increased. For change in season system, health risk has been increased.

The FGD participants said that pregnant women are facing safe delivery problem and dysentery. They are under health risk due to scarcity of safe water and poverty as

well as very little health services. Facilities of vaccination are inadequate.

Situation of water, sanitation, health and hygiene (WASH): The coastal people are surrounded by water but it is a fact that they have to undergo severe crisis of pure drinking and useable water. The findings of the study show that all the two Upazilas under study have the same problem in similar manner since a total of average 68% of the respondents have no safe water sources at their home while only 32% have that. Out of 32% safe source of water, 14% have hand tube-wells while the left 18% have deep tube-wells (Fig. 4).

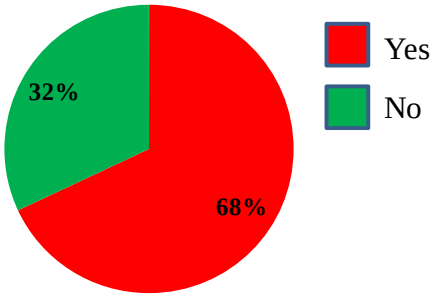

Fig. 4. Having safe source of water at home

The people having no safe source of water have to collect water from a distance of 0.25 to 2 km. causing a serious misery and waste of time. Moreover, 13% respondents informed that they have to face harassment in collecting water from the distannt place. Of the respondents, 17% think that the availability of safe water has decreased during the last five year's period which might be caused by the impact of climate change.

In case of any sickness, 86% people use to consult with quack doctors while only 12% visit doctors at the Upazilla Health Complex. Regarding use of the latrines, 55% told that they have to use non-sanitary latrines whereas 45% use sanitary ones (Ring-slab). None of the respondents use open places for defecation.

The study also revealed that 31% respondents use foot-wear while they go to latrine but 68% use the foot-wear regularly while they go latrine. The inhabitants of Subarna char use foot-wears occasionally. Majority of the respondents (59%) informed that they have not washed their hands with soap after use of latrine while 39% have practiced that (Fig. 5).

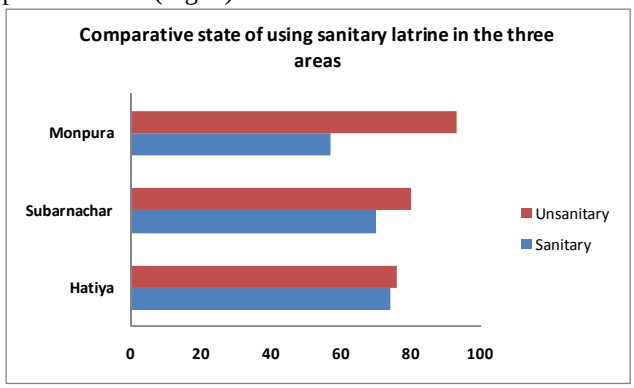

Fig. 5. Comparative state of using sanitary latrine

Loses due to disaster in 5 years: The study revealed that 86% respondents have been victims of any disaster during the last five year period. Choosing from multiple options for mentioning the damages, the highest (71%) responses have come on the damage of trees while 58% responses were about the damages of crops, 39% were about the death of livestock, and 23% were about the damage of fish cultivation.

The respondents mentioned that they have to leave with some common natural disasters which hit them almost every year and make them huge looses in terms of property and in some cases human lives. The following graph shows the five major threats to normalcy of life in the coastal areas (Fig. 6).

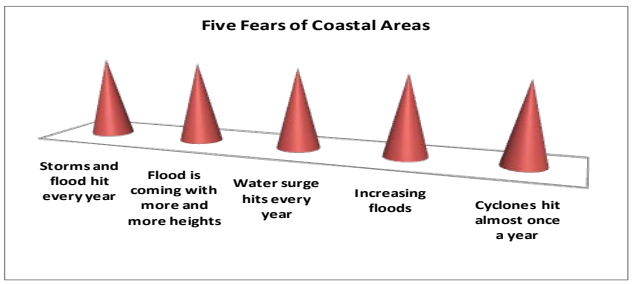

Fig. 6. Five fears of coastal areas

Facilities in the shelter centres: The respondents told that the distance of the cyclone shelters is most likely 0.5 km to the highest 3 km away from their homes. Twenty two percent respondents mentioned that the roads to the shelters are earthen and uneven. As per the statements of most of the respondents (91%), the shelters have no any special arrangement for the women and children. Almost all the respondents (92%) think that the women do not feel free to go to the cyclone shelters during disasters. All the respondents said that there was no special system for carrying the old aged/physically handicapped people to the cyclone shelters. Not only that, there was also no special arrangement for the old/physically handicapped people at the shelters. The respondents also mention that there is no facility to keep the livestock at the shelter centres (Fig. 7).

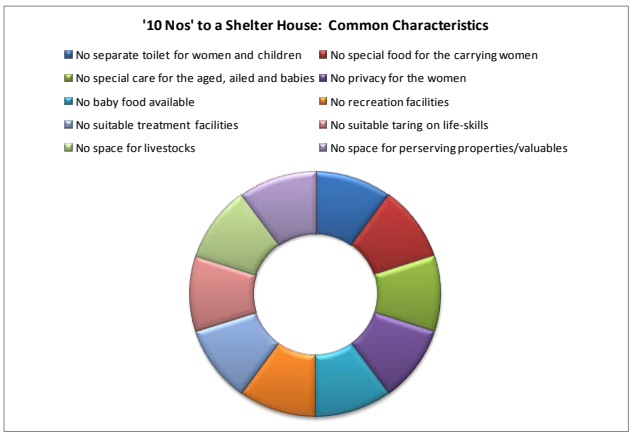

Fig. 7. Characteristics in shelter centres

The FGD participants mentioned that there are some privacy arrangements for women and separate toilets are available for them. The FGD and KII findings show that the shelter houses are not secured. They have no separate toilet arrangements and privacy for the women and children. There is no opportunity of the baby food and the special care provisions for the patients, persons with disabilities and old aged people.

Perceived impact of climate change: The respondents possessed mixed understanding about the impact of the climate change; Ninety five percent of them thought that climate change increased temperature of summer while 5% thought the reverse. Ninety three percent thought that temperature of winter has increased while 7% thought the reverse. Fifty seven per cent respondents thought that the climate change increased rain fall while 43% thought that it has decreased (Fig. 8).

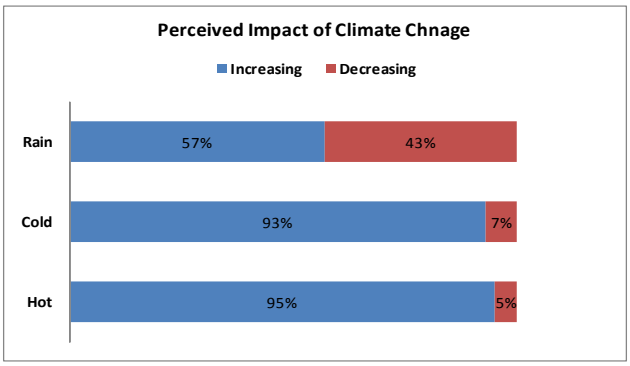

Fig. 8. Perceived impact of climate change

Forty three percent respondents thought that the climate change has decreased the crop production in their areas while 36% did not know about that. However, 21% directly opposed that.Twenty eight percent respondents told that they have noticed changes in agriculture in the last five years while the rest of the respondents (72%) have responded reverse. As per the statements of the respondents, all the changes are negative which include: falling of rice during harvesting, less production, decreasing fertility, crop production hampered due to increasing salinity and disasters.

The FGD participants informed that 80% people were under risk of migration due to increasing salinity, lack of social security, attacks of dacoits and pirates. Fishes are not available timely, fishermen are having less income. Fertility of land has been decreased, rain does not come timely, and these are causing less crop production. The KII and FGD participants reported that the adverse impacts of the climate changes have brought severe change in the system of 'Season Cycle' of the Bangladesh. Due to the adverse effects of the climate change, rain, weather and other basic elements of nature which are essential for growing crops and plants have been affected. As a result, people are suffering due to rising imbalanced situation in the 'eco-system'.

Problem of maintaining livestock: In maintaining livestock 31% respondents told they face problems while 32% said reversely. A remarkable proportion of the respondents (37%) do not know about the same. The people inhabited in Subarnachar were less affected with the problems than the other Upazila. The respondents mentioned that they have been facing different problems due to climate change as: (i) Scarcity of grass and other fodder, (ii) Water-logging, (iii) Small space for cattle rearing, (iv) Diseases, and (v) Blistering.

Problem with fishing: In catching fishes, 33% respondents said that they had to face problem due to climate change while 36% of the same opposed and the remaining 32% respondents have mentioned that they had not known about this. The people inhabited in Subarnachar are less affected with the problems than the other Upazila. The problems mentioned as: (i) Unavailability of fish, (ii) Water pollution in rivers, (iii) Increasing salinity, (iv) Irregular raining, and (v) Leaving no fish for reproduction/lack of brood fish.

Apart from these, the sudden sea surges are the causes of claiming lives of many fishermen every year. Floods and cyclones also create barriers and uncertainty in catching fishes smoothly.

Changes in homestead trees: Of the respondents, 36% mentioned that they have noticed changes in homestead trees while 22% responded reversely and 43% said that they have not known about the same. These changes have been mentioned in both upazilas in almost similar way. The changes mentioned as: (i) Inadequate growth of plants, (ii) Less fruits in trees, (iii) Disease infestations, (iv) Trees are dying unusually, (v) Insect attacks, and (vi) Fruits are falling in green.

Disaster signals: The 86% respondents told that the disaster signals are available to get in their regions while 14% told the reverse. The mass media like TV and Radio were the most important media of availing the signal related information as per the 57% respondent's views. While miking (use of loud speaker) was also very useful forinforming the people about disasters as per the 42% of the respondent's views.

Awareness of climate change: The study shows that majority of the respondents (56%) did not hear about the climate change while the rest of the respondents (44%) told that they heard about the matter. The ratio of the respondents from the two Upazillas having heard of the issue is almost similar. Mass media like television and radio have played significant role in informing the people of the climate change issues while interpersonal channels like UP Chairman/members, NGO representatives, government officials and relatives have also significant role in informing the people about climate change impact. The study revealed that television was the highest mentioned mass media of dissemination of climate change related information to the people.

The FGD participants said that various government services were extremely inadequate except some health services which were inadequate. The situation at Nijum dwip was worse.

Availability of social infrastructure: All the respondents said that they have schools in their villages and most of the families under survey have school going children who are the regular students. Only 39% respondents mentioned that they have community clinic in their localities while most of them told that the community clinic have no modern treatment facilities and specialized doctors for the community people. The services of the community clinics are only limited to rendering primary health care facilities. It has been revealed from the interviews that the community people have government offices like other upazillas, but they are not effective enough to address the shocks of climate changes. Most of the government offices perform their routine jobs rather serving the community people. Most of the respondents (65%) have mentioned

that they did not receive government services easily while only the 35% received them easily. The respondents have been lagging behind in receiving the government services than other upazilas. The respondents have mentioned some reasons for not getting services from the government offices which include: people's ignorance of the services; lack of understanding between the community people and service providers; people do not know the service providers' irresponsibility of the designated government officials; priority of the rich etc. (Fig. 9).

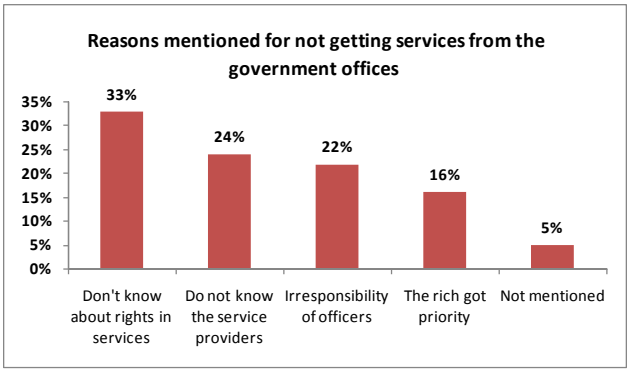

Fig. 9. Reasons for not getting Govt. office services

Only 15% respondents said that they have known the govt. steps/guidelines regarding disaster management while most of the respondents 85% have no idea about the same. Only 14% respondents felt satisfaction about the govt. activities for the management of climate change induced disasters while 86% said the reverse.

Only 18% respondents said that they knew the union disaster management committee (UDMC) while 82% of them were not aware of the UDMC. The respondents mentioned that they have known about the following activities of the UDMC:

The UDMC used to do different activities are: (i) Mass Awareness, (ii) Red-Crescent members are in the committee, (iii) Provide trainings for disaster preparedness, (iv) Do meetings, (v) Do relief works, and (vi) Disseminating disaster signals.

Only 20% of the respondents said that the UP chairman/ members did some functions regarding disaster management while 80% said that the UP members/ chairmen didnot do anything or the respondents were not aware of the matter. The respondents said that the UP chairman/members do different activities are: (i) Help people, (ii) Mass awareness, (iii) Water & sanitation works, (iv) Make list for relief distribution, and (vi) Dissemination of disaster signals.

Only 23% respondents said that there havebeen NGO activities in their village for disaster management due toclimate change. They mentioned the different NGO activities are: (i) Micro credit, (ii) Mass awareness, (iii) Water supply, (iv) Sanitary latrine supply, (v) Relief distribution, (vi) Disseminating disaster signals, and (vi) Construct houses.

Recommendations:

(i) Developing social infrastructures like construction of modern shelter houses, rich community clinics, education and training centers for supporting the disaster-hit people.
(ii) Creating of greenery through proper afforestation activities under the existing 'green belt' initiatives.
(iii) Creating mass awareness about the impacts of climate changes and its apparent threats and adaptation techniques.
(iv) Construction of durable embankments, switch gate and cross dams as per the felt needs of the communities.
(v) Development of communication and signaling system for accurate and timely weather forecasts.
(vi) Improving of the water and sanitation (WATSAN) system in the coastal regions.
(vii) NGOs, civil society and mass media should work collaboratelyon community wise disaster preparedness.
(viii) Initiating disaster resilient crop production.
(ix) Resolving land related disputes through appropriate settlement and rehabilitation of the sufferers.
(x) Generate alternative employment opportunities by the GO-NGO partnership.
(xi) Legal support to ensure social security.
(xii) Minimizing river erosion appropriately.
(xiii) Setting up educational institutions and other social infrastructures on the comparatively high land.
(xiv) Strengthening the local government and ensuring social security in the coastal region.
(xv) Protecting life and property of the coastal people through developing law and order.
(xvi) Enhancing social safety net programmes for the coastal areas.
(xvii) Supplying drought and salinity resistant seeds considering soil fertility.
(xviii) Planting trees befitting with the environment of the region.
(xix) Strengthening family planning and reproductive health activities.
(xx) Building more cyclone shelter houses in the most gender friendly atmosphere which will ensure facilities for the children, carrying and lactate mothers, PWDs, elderly people and adolescent girls.
(xxi) Setting up sanitary latrines and campaigning on good practices o health & hygiene.
(xxii) Improving communications system inside the villages and unions; and with national communication network.

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J. Agrofor. Environ. 11 (1 & 2): 41-47, 2017 ISSN 1995-6983

Sustainable utilization of fishery resources in the Andaman coastal areas, southern Thailand

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Abstract: Mangrove swamps provide rich diversity and high productivity of fishery resources and other fundamental ecological services for local inhabitants living in the coastal regions. We demonstrated in this study, fishing activities observed in front of mangrove swamps of the Andaman coastal areas, Ranong province, southern Thailand, to reveal the relationships between wetlands and the livelihood of local inhabitants, and discussed appropriate strategies to use sustainably the fishery resources. During the last 41 years, areas of natural mangrove forests decreased drastically, whereas areas of reservoirs, aquaculture ponds and aquaculture cages were largely increased due to the development of irrigation systems and aquaculture technologies. In Kamphuan village, 11.8-25.2 % of households were involved in fishing activities at the coastal waters in front of mangrove swamps. A total of 92 commercial fish species belonging to 46 families and 13 orders and a total of 48 commercial invertebrate species belonging to the 29 families, 15 orders and 5 phyla were classified into the taxonomic lists, most of which were the marine or brackish water species. Fishermen of Kamphuan village captured crabs, shrimps, squids, cuttlefishes, jellyfish, sand borer, sardines, mackerels, and some other fishes by means of various indigenous fishing gears. Shrimp net was the most popular fishing gear in this areas, followed by crab net, fish net, cuttlefish trap and fish trap. The efficient use of the indigenous fishing gears depended on understanding of fish behaviors, habitat and seasonal environmental conditions. Fishing gears and the target fishes were considerably different among the communities. By sharing the fishing gears, the fishing grounds and the target species, local inhabitants could avoid competition for fishery resources each other, and consequently, utilize sustainably natural fishery resources in the coastal areas.
Key words: Fishery resources, fishing gear, coastal fishery, mangrove, Andaman sea.

Introduction

In the tropical coastal regions, mangrove swamps are playing important roles for aquatic organisms to supply breeding sites, spawning sites, nursery grounds and potential sources of food. They provide rich natural resources and other fundamental ecological services for local inhabitants living in the coastal regions. In particular, fishery resources support their livelihood to obtain protein sources and stable cash income. Understanding their routine fishing activities as well as diversity and productivity of fishery resources are important to promote sustainable utilization of the mangrove swamps.

In coastal regions, however, mangrove forests decreased drastically due to intensive shrimp aquaculture, charcoal making, urbanization and some other reasons (Hogarth 1999, Barbier and sathirathai, 2004, Patanaponpaiboon 2010). As the result, capture fishery production decreased remarkably in coastal regions of Thailand (DOF 2008, FAO 2010, 2011). Appropriate management and conservation of the mangrove swamps and the coastal areas are utmost important for utilizing sustainably the fishery resources.

We demonstrated in this study, fishing activities observed in front of mangrove swamps of the Andaman coastal areas, southern Thailand, to reveal the relationships between fishing activities and livelihood of local inhabitants, and discussed appropriate strategies to utilize sustainably the fishery resources, following the previous studies (Fujioka *et al.* 2010b, 2012).

Materials and Methods

We studied fishing activities in the Andaman coastal areas of the southern Thailand. Study sites were selected at the mangrove swamps and the shallow coastal areas in front of Kamphuan and Naka villages, Suksamran district, Ranong province, the Kingdom of Thailand (Fig. 1). This areas is located near the Myanmar border, and is well known as one of the largest production centers of fishery resources in southeastern Asia. The mangrove forests and the benthic organisms have been investigated for several years in and around the Andaman coastal research station for development (Ranong coastal resources research station) (9°22'37"N, 98°23'53"E), Kasetsart University, by our survey teams (Matsumoto *et al.*, 2006, Tabuchi 2010, Fujioka *et al.*, 2010a, Sano *et al.*, 2012).

In this study, we demonstrated that (1) aquatic organisms and fishery resources, (2) fishing activities in the coastal areas, and (3) livelihood of fishermen from the biological, fisheries and social scientific standpoints, respectively. In addition to administrative information about population and fishery statistics of Kamphuan and Naka villages, we obtained knowledge about local fisheries by interviewing village mayor and every community leaders. Furthermore we carried out systematic questionary investigation for 22 fishermen of the Kamphuan village and 8 fishermen of the Naka village to obtain detailed knowledge about fishing grounds, fishing gears, fishery production and other routine activities. Land use in the coastal areas of Suksamran district was investigated based on the Sano's (Sano *et al.*, 2012) landscape analysis using the aerial photograph and satellite image during the last 41 years from 1966 to 2007.

This study was implemented in collaboration and coordination among several Japanese and Thailand research institutes; that is, National Research Institute of Aquaculture, Japan (NRIA), Forestry and Forest Products Research Institute, Japan (FFPRI), Kasetsart University, Thailand (KU) and the Chulalongkorn University, Thailand (CU).

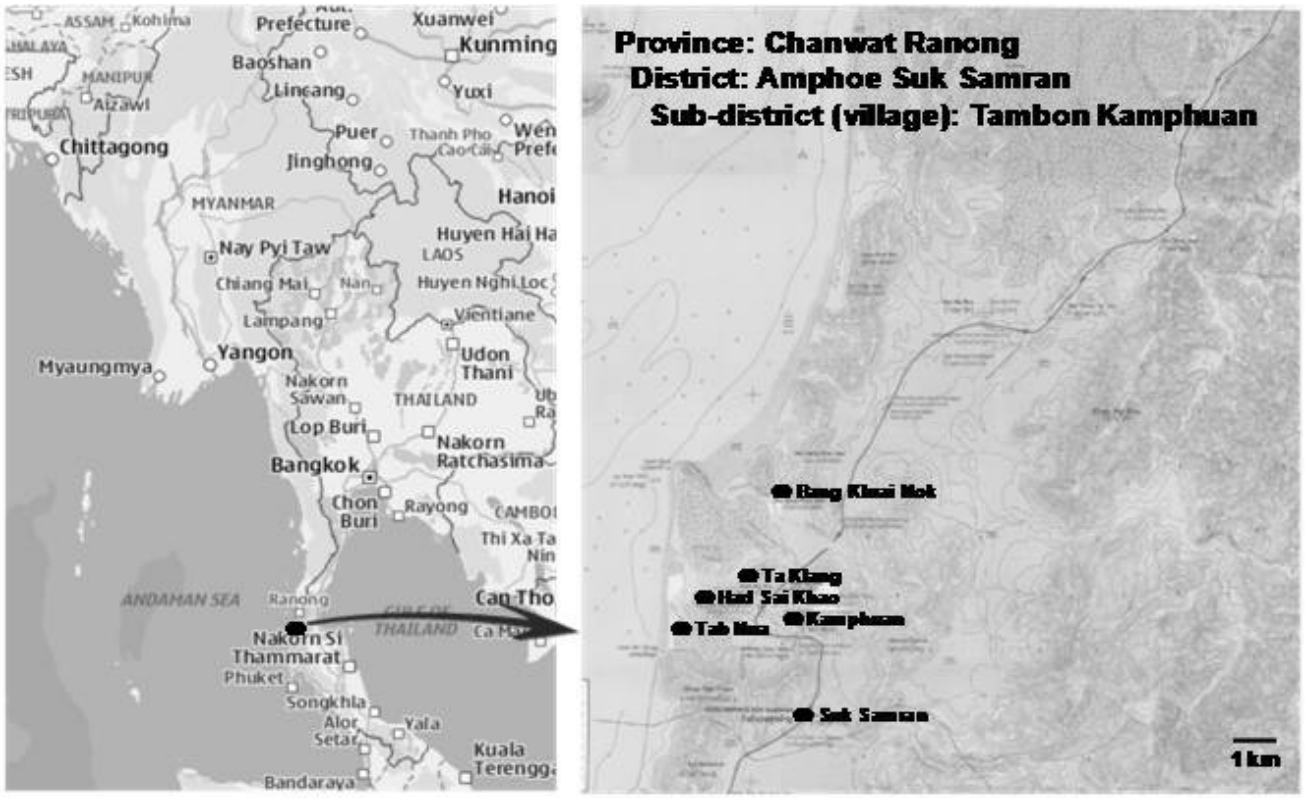

Fig. 1. Map of southern Thailand

Results and Discussion

Sano *et al.*(2012) demonstrated land use in the coastal areas of Kamphuan village, Ranong province, based on the landscape analysis using the aerial photograph and satellite image. They classified approximately 120 km^2 coastal areas into 22 categories as shown in Fig. 2. Areas of natural forests (terrestrial forest, terrestrial shrub, mangrove forest, mangrove shrub and swamp forest) decreased from 52.4 % (6429.4 ha) to 37.7 % (4626.8 ha) during the 41 years from 1966 to 2007, in which the mangrove forests decreased remarkably from 797.6 ha to 53.9 ha. Whereas artificial changes were predominantly found in the areas of rubber and palm plantation, construction of villages and roads and aquaculture facilities.

Based on the landscape analysis of satellite image in 1997, spatial configuration of four categories concerning water systems; that is, river/sea, reservoir, aquaculture pond and aquaculture cage, was redrawn and separately exhibited in Fig. 2. Complicated water network of river tributaries was observed in the coastal areas since the mangrove swamps were topographically very flat and little difference in elevation. Although there was nothing areas for the latter three categories, reservoir, aquaculture pond and aquaculture cage, in 1966 (Sano *et al.* 2012), the areas increased to 22.9 ha, 295.5 ha and 54.2 ha, respectively, in 2007 (Fig. 2), due to the development of irrigation systems and aquaculture technologies in recent years. Intensive shrimp culture technologies for *Penaeus monodon* and *P. vannamei* spread throughout the southeast Asia over the last three decades and a lot of mangrove forests changed to the aquaculture ponds (Barbier *et.al.* 2004). Fish aquaculture technologies by means of floating cage were also developed in recent years at the brackish waters around the mangrove estuaries.

In Kamphuan village, Ranong province, 5,695 inhabitants of 1,647 households were living in seven coastal communities; that is, Talay Nork, Tub Nua, Kamphuan, Ta Klang, Suk Samran, ToanKhoa and Hat Sai Khao (Table 1). Among them 199 households engaged in fisheries. In the four main fishermen villages, Talay Nork, Kamphuan, Ta Klang and Had Sai Khao, 11.8-25.2 % of households were involved in fishing activities at the coastal waters in front of mangrove swamps. Most fishermen had their own fishing boats, and a total of 261 fishing boats were present in the Kamphuan village. Five of them were the medium-sized vessels of about 17-34 metric tons and the remaining 256 were small boats less than 1 metric ton.

Commercial fish species and commercial invertebrate species found in the coastal areas of Ranong province were classified into the taxonomic lists (Table 2, Table 3), which were based on the present study, comprehensive study about molluscan fauna (Fujioka *et al*., 2007) and field survey of fish marketing system (Fujioka, unpublished). Thereby, in addition to captured fishes and cultured fishes, fishes sold in local and central markets were included in the lists. A total of 92 commercial fish species belonging to 46 families and 13 orders were hitherto identified (Table 2). A total of 48 commercial invertebrate species belonging to the 29 families, 15 orders and 5 phyla were also hitherto identified (Table 3). Most of them were marine or brackish water species, and there were a few freshwater ones.

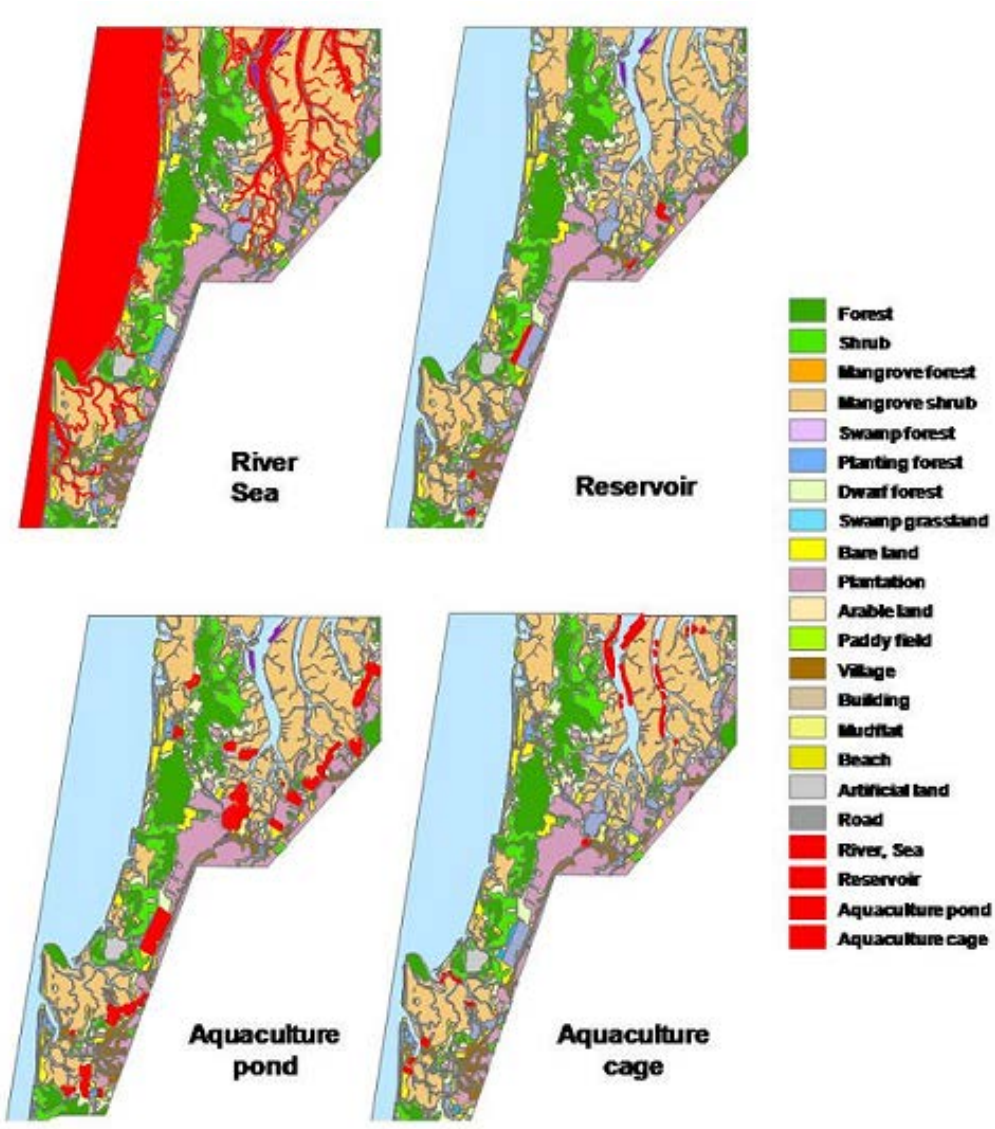

Fig. 2. Land use and water systems of Suksamran district, Ranong province, in 1997.

Fishermen of Kamphuan village captured crabs (*Portunus pelagicus, P. sanguinolentus, Charybdis feriatus* and *Thalamita crenata*), shrimps (*Penaeus merguiensis* and *P.* spp.), squids (*Sepioteuthis lessoniana, Photololigo duvauceli* and *P. chinensis*), cuttle fishes (*Sepia pharaonis* and *S.* spp.), and borer (*Sillago sihama*), sardines (*Amblygaster clupeoides*), mackerels (*Rastrelliger kanagurta*), shads (*Anodontosto machacunda*), scads (*Selarcrumenoph thalmus*), snappers (*Lutjanus russellii* and *L.*spp.), goatfishes (*Parupeneus heptacanthus*), jellyfish (*Lobonemoides rubustus* and *L.* spp.) and Mysis (*Mysis* spp.). Besides, fishermen cultured some kinds of fishes and shells in the aquaculture cages along the river side near the mangrove estuaries; that is, giant seaperch (*Latescal carifer*), John's snapper (*Lutjanus johnii*), greasy grouper (*Epinephelus tauvina* and *E. coioides*), niletilapia (*Oreochromis niloticus*) and green mussel (*Perna viridis*). In the coastal aquaculture ponds, intensive shrimp culture for *Penaeusvan namei* and *P. monodon* were carried out.

Fishing gears observed in Kamphuan village were shown in Fig. 3. They operated various kinds of fishing gears; that is, shrimp net {Fig. 3 (1)}, crab net {Fig. 3 (2)}, sand borer net {Fig. 3 (3)}, sardine/mackerel net (Fig. 3 (4)), squid net (Fig. 3 (5)), cuttlefish trap {Fig. 3 (6)}, fish trap {Fig. 3 (7)-(9)}, crab trap {Fig. 3 (10)}, push net (Fig. 3 (11)), scoop net (Fig. 3 (12)), handy dredge {Fig. 3 (15)} and other miscellaneous fishing gears. Aquaculture pond {Fig. 3 (13)} and aquaculture cage {Fig. 3 (14)} were also shown in Fig. 3. The efficient use of the indigenous fishing gears, especially trap fishing gears, depended on understanding of fish behaviors, habitat and seasonal environmental conditions.

Based on the administrative information about fisheries, fishing gears operated in seven communities of Kamphuan village and one neighboring community (Bang KruaiNok) of the Naka village were summarized in Fig. 4. Except for the small fishing gears (push net, scoop net and handy dredge), a total of 474 fishing gears were recognized in this areas. Shrimp net was the most popular fishing gear in this areas, followed by crab net and fish net, all of which were the kinds of gill nets and common in easy operation, simple structure and low investment cost. The length, the height and the mesh size were different according to the target species. Cuttlefish trap and fish trap included

several types of cage traps and were also popular in this areas.

Table 1. Population composition and fishermen in Kamphuan village, Ranong province.

No.	Village name	Population	No. of household	Fisherman household		No. of boat
				number	%	
1	Talay Nork	264	74	13	17.6	15
2	Tub Nua	1397	422	27	6.4	29
3	Kamphuan	1255	321	38	11.8	56
4	Ta Klang	1367	364	59	16.2	74
5	Suk Samran	567	167	1	0.6	2
6	Toan Khoa	284	65	2	3.1	2
7	Hai Sai Khao	561	234	59	25.2	83
	Total	5695	1647	199	12.1	

Table 2 Commercial fish species in the Andaman coastal areas of Ranong province, southern Thailand.

Phylum Chordata	
Class Chondrichthyes	
Order Lamniformis	
Family Sphyrnidae	
Sphyrna lewini (Griffith & Smith, 1834)	Scalloped hammerhead shark
Order Carcharhiniformes	
Family Carcharhinidae	
Rhizoprionodon acutus Rüppell, 1837	Milk shark
Order Rajiformis	
Family Rhinobatidae	
Rhynchobatus djiddensis (Forsskal, 1775)	Giant guitarfish
Family Dasyatidae	
Dasyatis zugei (Muller and Henle,1841)	Pale-edged stingray
Himantura imbricata (Bloch & Schneider, 1801)	Scaly whipray
Class Osteichthyes	
Order Clupeiformes	
Family Clupeidae	
Tenualosa toli (Valenciennes, 1847)	Toli shad
Tenualosa macrura (Bleeker, 1852)	Longtail shad
Anodontostoma chacunda (Hamilton, 1822)	Chacunda gizzard shad
Amblygaster clupeoides Bleeker, 1849	Bleeker's smoothbelly sardinella
Family Chirocentridae	
Chirocentrus nudus Swainson, 1839	Whitefin wolf-herring
Family Engraulidae	
Stolephorus indicus (van Hasselt, 1823)	Indian anchovy
Stolephorus sp.	Anchovy
Thyssa sp.	Tyssa
Order Elopiformes	
Family Megalopidae	
Megalops cyprinoides (Broussonet, 1782)	Indo-Pacific tarpon
Order Anguilliformes	
Family Muraenesocidae	
Congresox talabon (Cuvier, 1829)	Yellow pike conger
Order Gonorynchiformes	
Family Chanidae	
Chanos chanos (Forsskal, 1775)	Milkfish
Order Siluriformes	
Family Ariidae	
Netuma thalassinus (Ruppell, 1837)	Giant sea catfish
Family Plotosidae	
Plotosus canius Hamilton, 1822	Gray eel catfish, Eel catfish
Plotosus lineatus (Thunberg, 1787)	Striped eel catfish
Order Myctophiformes	
Family Synodontidae	
Saurida undosquamis (Richardson, 1848)	Brushtooth lizardfish
Order Beloniformes	
Family Hemiramphidae	
Hyporhamphus melanopterus Collette & Parin, 1978	Blackfinned halfbeak
Hyporhamphus quoyi (Valenciennes, 1847)	Quoy's garfish
Order Perciformes	
Family Mugilidae	
Liza vaigiensis (Quoy & Gaimard, 1825)	Squaretail mullet
Liza subviridis (Valenciennes, 1836)	Greenback mullet
Valamugil buchanani (Bleeker, 1853)	Bluetail mullet
Family Cichlidae	
Oreochromis niloticus (Linnaeus, 1758)	Nile tilapia
Oreochromis niloticus var.	Taptim
Family Sphyraenidae	Obtuse barracuda
Sphyraena obstusata Cuvier, 1829	
Family Polynemidae	Striped threadfin
Polydactylus plebeius (Broussonet, 1782)	Indian threadfin
Polydactylus indicum (Shaw, 1804)	
Family Centropomidae	Giant sea perch
Lates calcarifer (Bloch, 1790)	
Family Ambassidae	Perchlet, Glassfish
Ambassis sp.	
Family Serranidae	Orange-spotted grouper
Epinephelus coioides (Hamilton, 1822)	Greasy grouper
Epinephelus tauvina (Forsskal, 1775)	
Family Priacanthidae	Purple-spotted bigeye
Priacanthus tayenus Richardson, 1846	
Family Sillaginidae	Silver sillago
Sillago sihama (Forsskal, 1775)	Oriental trumpeter whiting
Sillago aeolus (Jordan & Evermann, 1902)	
Family Rachycentridae	Cobia
Rachycentron canadum (Linnaeus, 1766)	
Family Carangidae	
Elagatis bipinnulata (Quoy & Gaimard, 1825)	Rainbow runner
Seriolina nigrofasciata (Ruppell, 1829)	Blackbanded trevally
Scomberoides lysan Forsskal, 1775	Doublespotted queenfish
Scomberoides commersonnianus Lecepede, 1801	Talang queenfish
Decapterus maruadsi Tamminck & Schlegel, 1843	Japanese scad
Decapterus russelli (Ruppell, 1830)	Indian scad, Round scad
Selar boops (Cuvier, 1833)	Oxeye scad
Selar crumenophthalmus (Bloch, 1793)	Bigeye scad
Atule mate (Cuvier, 1833)	Yellowtail scad
Selaroides leptolepis (Cuvier, 1833)	Yellowstripe scad
Megalaspis cordyla (Linnaeus, 1758)	Torpedo scad
Caranx ignobilis (Forsskal, 1775)	Giant trevally
Caranx melampygus (Cuvier, 1833)	Bluefin trevally
Carangoides coeruleopinnatus (Ruppell, 1830)	Coastal trevally
Carangoides ferdau (Forsskal, 1775)	Blue, trevally
Carangoides hedlandensis (Whitley, 1934)	Bumpnose trevally
Alectis ciliaris (Bloch, 1787)	African pompano
Family Leiognathidae	
Leiognathus decorus (De Vis, 1884)	Decorated ponyfish
Leiognathus equulus (Forsskål, 1775)	Common ponyfish
Leiognathus sp.	Ponyfish
Secutor insidiator (Bloch, 1787)	Pugnose ponyfish
Family Lobotidae	
Lobotes surinamensis (Bloch, 1790)	Tripletail
Family Gerreidae	
Gerres filamentosus Cuvier, 1829	Whipfin silver-biddy
Family Sciaenidae	
Nibea semifasciata Chu, Lo & Wu, 1963	Sharpnose croaker
Pennahia anea (Bloch, 1793)	Bigeye croaker
Family Mullidae	
Parupeneus heptacanthus (Lacepède, 1802)	Cinnabar goatfish
Family Lutjanidae	
Lutjanus johnii (Bloch, 1792)	John's snapper
Lutjanus malabaricus (Bloch & schneider, 1801)	Malabar blood snapper
Lutjanus monostigma (Cuvier, 1828)	Onespot snapper
Lutjanus russellii (Bleeker, 1849)	Russell's snapper
Lutjanus sebae (Cuvier, 1816)	Emperor red snapper
Family Pomadasyidae	
Pomadasys kaakan (Cuvier, 1830)	Javelin grunter
Diagramma pictum (Thunberg, 1792)	Painted sweetlips
Family Terapontidae	
Terapon jarbua (Forsskål, 1775)	Crescent perch
Family Nemipteridae	
Nemipterus hexodon (Qouy & Gaimard, 1824)	Ornate threadfin bream
Family Lethrinidae	
Lethrinus lentjan (Lacepede, 1802)	Pink ear emperor
Family Ephippididae	
Drepane punctata (Linnaeus, 1758)	Spotted sicklefish
Ephippus orbis (Bloch, 1787)	Orbfish, Spadefish
Family Scatophagidae	
Scatophagus argus (Linnaeus, 1766)	Spotted scat, Spadefish
Family Caesionidae	
Caesio cuning (Bloch, 1791)	Redbelly yellowtail fusilier
Family Trichiuridae	
Trichiurus lepturus Linnaeus, 1758	Largehead hairtail
Family Scombridae	
Rastrelliger kanagurta (Cuvier, 1817)	Indian mackerel
Scomberomorus commerson (Lacepede, 1800)	Narrow-barred Spanish
Euthynnus affinis (Cantor, 1849)	Eastern little tuna, Kawakawa
Thunnus tonggol (Bleeker, 1851)	Longtail tuna
Family Siganidae	
Siganus canaliculatus (Park, 1797)	Whitespotted spinefoot
Siganus javus Linnaeus, 1766	Streaked spinefoot
Family Stromateidae	
Pampus argenteus (Euphrasen, 1788)	Silver pomfret
Pampus chinensis (Euphrasen, 1788)	Chineses silver pomfret
Family Gobiidae	
Periophthalmus argentilineatus Valenciennes, 1837	Barred mudskipper
Order Pleuronectiformes	
Family Paralichthyidae	
Psettodes erumei (Bloch and Schneider, 1801)	Indian halibut
Family Cynoglossidae	
Cynoglossus lingua Hamilton, 1822	Long tonguesole
Order Tetraodontiformes	
Family Monacanthidae	
Aluterus monoceros (Linnaeus, 1758)	Unicorn leatherjacket

Table 3 Commercial invertebrate species in the Andaman coastal areas of Ranong province, southern Thailand.

Phylum Mollusca	
Class Gastropoda	
Order Vetigastropoda	
Family Haliotidae	
Haliotis asinina Linnaeus, 1758	Donkey's-ear Abalone
Order Discopoda	
Family Viviparidae	
Filopaludina spp.	Pond snail, River snail
Family Turritellidae	
Turritella terebra (Linaeus, 1758)	Screw turritella, Auger terebra
Family Potamididae	
Cerithidea obtusa (Lamarck, 1822)	Blunt creeper, Horn snail
Family Strombidae	
Strombus canarium Linnaeus, 1758	Dog conch
Order Neogastropoda	
Family Buccinidae	
Babylonia spirata (Linnaeus, 1758)	Spiral babylon
Babylonia areolata (Link, 1807)	Spotted babylon
Family Volutidae	
Melo melo (Lightfoot, 1786)	Indian volute, Bailer shell
Family Melongenidae	
Pugilina cochlidium (Linnaeus, 1758)	Spiral melongena
Class Bivalvia	
Order Arcoida	
Family Archidae	
Anadara granosa (Linnaeus, 1758)	Granular ark
Scapharca troscheli (Dunker, 1832)	Ark
Order Mytiloida	
Family Mytilidae	
Perna viridis (Linnaeus, 1758)	Asian green mussel
Order Ostreoida	
Family Pectinidae	
Amusium pleuronectes (Linnaeus, 1758)	Radiated scallop
Family Ostreidae	
Saccostrea forskali (Gmelin, 1791)	Indian rock oyster
Order Heterodonta	
Family Donacidae	
Donax spp.	Bean clam
Family Corbiculidae	
Geloina erosa (Lightfoot, 1786)	Common geloina
Family Veneridae	
Tapes dorsatus (Lamarck, 1818)	Turgid venus
Meretrix meretrix (Linnaeus, 1758)	Oriental clam
Class Cephalopoda	
Order Sepioida	
Family Sepiidae	
Sepia pharaonis Ehrenberg, 1831	Rainbow cuttlefish
Sepia spp.	Cuttlefish
Family Loliginidae	
Sepioteuthis lessoniana (Lesson, 1830)	Bigfin reef squid
Photololigo duvauceli (d'Orbigny, 1848)	Indian squid
Photololigo chinensis Gray, 1849	Mitre squid
Order Octopoda	
Family Octopodidae	
Amphioctopus aegina (Gray, 1849)	Sandbird octopus
Octopus sp.	Octopus
Phylum Arthropoda	
Class Melacostraca	
Order Stomatopoda	
Family Squillidae	
Oratosquilla nepa (Latreille, 1828)	Mantis shrimp
Order Mysida	
Family Mysidae	
Mysis spp.	Mysis
Order Decapoda	
Family Thalassinidae	
Thalassina anomala (Herbst, 1804)	Mud lobster
Family Penaeidae	
Penaeus merguiensis De Man, 1888	Banana prawn
Penaeus monodon Fabricius, 1798	Giant tiger prawn
Penaeus vannamei Boone, 1931	Whiteleg shrimp
Penaeus spp.	
Family Palaemonidae	
Macrobrachium sp.	Dwarf prawn
Family Palinuridae	
Panulirus versicolor (Latreille, 1804)	Blue spiny lobster
Panulirus polyphagus (Herbst,1793)	Mud spiny lobster
Panulirus ornatus (Fabricius, 1798)	Ornate spiny lobster
Thenus orientalis (Lund, 1793)	Slipper lobster
Family Portunidae	
Portunus pelagicus (Linnaeus, 1758)	Blue swimming crab
Portunus sanguinolentus (Herbst, 1783)	Three spot swimming crab
Portunus gladiator Fabricius, 1798	Swimming crab
Charybdis feriatus (Linnaeus, 1758)	Crucifix crab
Thalamita crenata (Latreille, 1829)	Spiny rock crab
Scylla serrata Forskal, 1775	Serrated mud crab
Family Grapsidae	
Parasesarma spp.	marsh clab
Phylum Echinodermata	
Class Holothuroidea	
Order Aspidochirotida	
Family Holothuriidae	
Holothuria atra Jaeger, 1833	Black sea cucumber
Phylum Tentaculata	
Class Brachiopoda	
Order Lingulida	
Family Lingulidae	
Lingula anatina (Lamarck, 1801)	Lamp shell
Phylum Cnidaria	
Class Scyphozoa	
Order Rhizostomae	
Family Lobonematidae	
Lobonemoides rubustus Stiasney, 1920	Jellyfish
Lobonemoides spp.	Jellyfish

Fishing gears and the target fishes were considerably different among the communities (Fig. 5). Shrimp net was carried out in common throughout all the communities. Crab net was very popular in four communities, Tab Nua, Kamphuan, Ta Klang and Hat Sai Khao. Fish net was also popular in three communities, Kamphuan, Ta Klang and Hat Sai Khao. Most of the fish nets were used to catch sand borer (*Silla gosihama*) inhabiting bottom layer of the shallow waters. Mackerel net and sardine net were uncommon because they required big fishing boat with mechanized equipments. Cuttlefish trap was popular only in two communities, Kamphuan and Hat Sai Khao. Fish trap was dominant in Talay Nork community but not popular in other communities.

Differences in the kinds of fishing gears among every communities might be related to the diffusion process of theindigenous fishing technologies because relatives and neighbors who live in the same communities tended to select similar fishing gears. It seemed to have an advantage on the marketing system to be able to sell fishery products for buyers and wholesalers within the same communities. Consequently, to share the fishing

gears and the target species was a voluntary wisdom for local communities.

Fig. 3. Fishing gears in the coast of Kamphuan village, Ranong province, Southern Thailand.

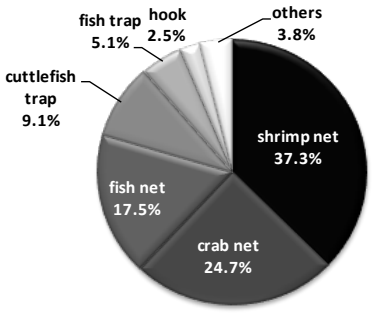

Fig. 4 Fishing gears in Kamphuan village, Ranong province.

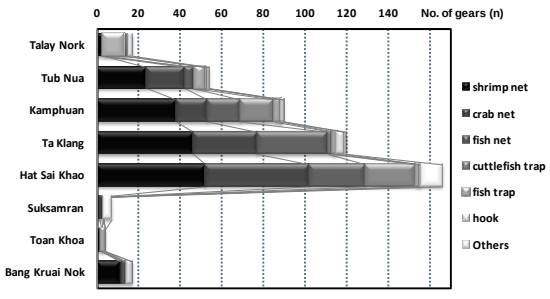

Fig. 5 Fishing gears in every communities of Kamphuan village, Ranong province.

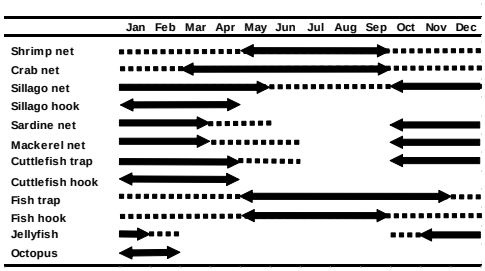

Fig. 6 Seasonality of fishing activities in the coast of Kamphuan village, Ranong province.

Solid lines: high fishing season, dotted line: low fishing season

Seasonality of every fishing activities in the coast of Kamphuan village was summarized in Fig. 6. Fishing by means of shrimp net and crab net were carried out throughout the year, but they were predominantly operated during the rainy season from March to September. The fishing season is closely related the breeding season of these species because they migrate to the shallow waters during the breeding season. Likewise, sillago (sand borer: *Silla gosihama*) net was carried out throughout the year, but it was predominantly operated during the dry season from October to May. Sardine net and mackerel net were operated predominantly in the dry season from October to March. Cuttlefish trap and cuttlefish hook were also restricted in the dry season from October to April. Fish trap and fish hook were carried out throughout the year and predominantly operated in the rainy season from May to November. Jellyfish fishing by means of scoop net was restricted only a few months from November to January because a huge number of jellyfish were transported by monsoon toward the eastern side of Andaman coast. Thus, seasonality of every fishing activities was closely related to the life cycle and the behaviors of target species.

It is well known that rich biodiversity and high productivity were found in the coastal areas around mangrove swamps because a lot of fishes, crustaceans, molluscs and other aquatic organisms use mangrove swamps as breeding sites, spawning sites, nursery grounds and shelter as well as feeding site during a certain stage of their life cycle (Robertson *et.al.*, 1992). After growing up, they were distributed in every habitats in the coastal areas, and therefore, the fishing grounds in the coastal areas of Kamphuan village were different each other depending on the habitat of the fishery resources (Fig. 7). Most fishing activities were carried out within 3 km from the coastline, where fishermen of coastal communities had an exclusive right to catch fishery resources. In Kamphuan and Naka villages, every fishing boats was located in four major fishing ports; Tab Nua, Ta Klang, Hat Sai Khao and Bang KruaiNok (Fig. 7). Fishing boats set off from these four fishing ports to their own fishing grounds through the mangrove estuaries. By sharing the fishing gears and the target fishes, fishermen could avoid competition on the fishing grounds within the coastal areas.

Mangrove swamps provided fundamental ecological services of abundant fishery resources for local inhabitants living along the coastal areas. The efficient use of various indigenous fishing gears depended on understanding of fish behaviors, habitat and seasonal environmental conditions. By sharing the fishing strategies, local

inhabitants could avoid competition for fishery resources each other, and consequently, utilize sustainably natural fishery resources in the coastal areas.

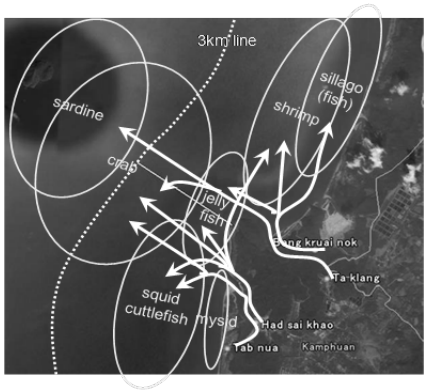

Fig. 7 Fishing grounds and fishing activities in the coast of Kamphuan village, Ranong province.

Acknowledgements: We are grateful to inhabitants and fishermen who gave us a lot of valuable knowledge about fishing activities and village livelihoods. This study was supported by the Global Environment Research Fund (D-0902) of the Ministry of the Environment, Japan.

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J. Agrofor. Environ. 11 (1 & 2): 49-54, 2017 ISSN 1995-6983

Natural disasters in Bangladesh and Japan - comparing its scale and damages

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Abstract: Bangladesh is located on the Bengal delta made by sediments from Himalayas and, on the other hand, Japan is the isolated islands surrounded by sea, which makes the difference between these two countries in scale, frequencies and damages of natural disasters. During a last hundred years, the storm and the earthquake occurred frequently and caused a lot of damages to human life and national economy in Japan. In contrast, the storm and the flood have been worst natural disasters in Bangladesh. Frequency of the storm in both country are almost same but the number of deaths in Bangladesh are 18 times more than that of Japan. Frequency and the deaths of flood in Bangladesh are larger than those of Japan although total amount of damage is equivalent. The economic damage of Bangladesh is 2.4 times larger than that of Japan in the percentage of GDP although total real damage amount of Japan is 20 times larger than that of Bangladesh. The fact shows Bangladesh has economically received bad influences not at all inferior to Japan.
Key words: Bangladesh, Japan, natural hazards, disaster management.

Introduction

Bangladesh is located on one of the biggest deltas in the world which has been made by three large rivers. The Ganges and Brahmaputra rivers transport enormous run-off and soil from the Himalayan drainage system (or Himalayan river basin system) and another big river Meghna gathering top of the world's amount of rainfall from Meghalaya joins in the country. The plain topography of delta and massive amount of water creates a characteristic hydrological zone which is often flooded with river channel erosion. Moreover, the country is facing the Bay of Bengal which is opening way for cyclones. Thus the combination of such facts the country is located on the end of Himalayan watershed and faces the Bay of Bengal makes Bangladesh a country of “natural disasters” (Fig. 1a). On the other hand, Japan is located in the circum-Pacific mobile zone where seismic and volcanic activities occur frequently. Japan itself stands on four tectonic plates some of which are subducting and pushingeach other as shown in Fig. 1b. Such moving tectonic plates make the country unstable geologically and it is said there are many active fault lines more than 2,000 in Japan. Due to such geographical and geological condition, number of earthquakes with magnitude of six or greater recorded 190 in a decade (1996-2005) which is 20% of total in the world and number of active volcanos is 108 equal 7% of the total (GoJ. 2002).

Moreover, because the national land extending north, south, east and west widely is surrounded on all four sides by sea, it is also subject to meteorological disasters such as typhoons, torrential rains and heavy snow. In this paper the author compares damages of natural calamities in both countries about its scale and frequency.

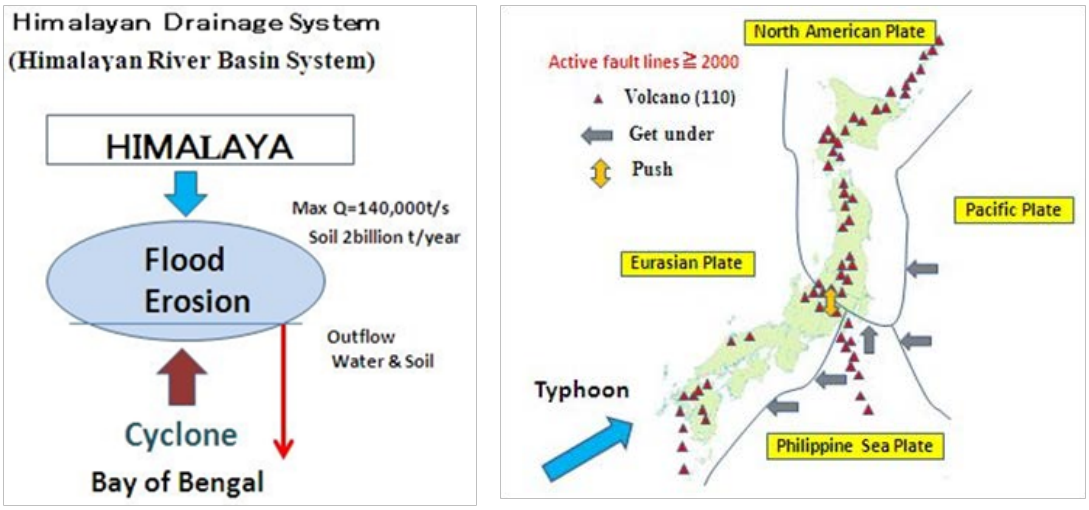

Fig. 1. Location and natural disasters in Bangladesh (A) and Japan (B)

Materials and Methods

Since 1988 the WHO Collaborating Center for Research on the Epidemiology of Disasters (CRED) in Belgium has been maintaining an Emergency Events Database EM-DAT. EM-DAT contains essential core data on the occurrence and effects of over 18,000 mass disasters in the world from 1900 to present. The database is compiled from various sources, including UN agencies, non-governmental organizations, insurance companies, research institutes and press agencies.

In order for a disaster to be entered into the database at least one of the following criteria has to be fulfilled: (i) 10

or more people reported killed, (ii) 100 people reported affected, (iii) a call for international assistance, (iv) declaration of state of emergency.

The author discusses about the natural disasters in Japan and Bangladesh using the summarized tables of five kinds of natural disasters (earthquake, flood, landslide, storm and drought) which seemed to be important for both countries. Moreover, tables of top ten natural disasters sorted by numbers of death, sufferer and economic damage are also referenced secondarily. All data for making tables are recorded between 1900 and 2013. The used EM-DAT database version is 12.07 created on July 29, 2013(OFDA/CRED 2013).

Results and Discussion

Frequency, number of death and sufferer, worst 10 natural disasters

Table 1 shows frequencies of main five natural disasters in Japan and Bangladesh between 1900 and 2013. Table 2 indicates the number of deaths and sufferers by five disasters respectively and Table 2 lists worst 10 disasters in regard to number of death during the same period.

Table 1. Natural Disasters in the two countries (Frequency)

(1900-2013)[1,2]

Disaster	Frequency	
	Japan	Bangladesh
Earthquake[3]	57	7
Flood[4]	47	85
Landslide	21	3
Storm[5]	149	165
Drought	1	7
Total	275	267

1.EM-DAT:The OFDA/CRED International Disaster Database
2.10 more killed/100 more affected/emergent declare/call international assistant
3.inc. TSUNAMI 4.inc. storm surge, coastal flood 5.inc. cyclone, typhoon, local one

Earthquake: As mentioned in the previous chapter, the frequency of earthquake in Japan is eight times as high as in Bangladesh (Table 1) and total number of deaths by earthquakes during a century is by far highest in all natural disasters in Japan (Table 2). Moreover, top four causes of highest number of deaths are earthquakes and half of the worst top 10 disasters are also earthquakes in Japan (Table 3). On the other hand, very little victim of earthquakes can be seen and there is not any earthquake ranked in worst top ten disasters in Bangladesh (Table 2 and 3).

Regarding Japan, it is remarkable that both of massive earthquakes, namely the 2011 off the Pacific coast of *Tohoku* Earthquake which had largest magnitude of 9.0 in recorded history and *Han-Shin Awaji* Earthquake disaster of 1995 which was a typical inland earthquake, occurred within these two decades. Moreover, recent earthquakes have brought in new social problems such as sense of emergency of the strong urban earthquake and sense of weakness against nuclear electric power generation. Following these several events the Japanese government has pointed out with a great sense of urgency that Japan can be struck by large-scale earthquakes in the next few decades. Especially, large-scale earthquakes around *Nankai* Trough, trench type earthquakes in the vicinity of the Japan and *Chishima* Trenches and Tokyo inland earthquake are attracting attentions (JoG. 2002).

Table 2. Natural Disasters in two countries (Deaths and sufferers)

(1900-2013)[1,2]

	Deaths(1,000)		Sufferers(1,000)	
	Japan	Bangladesh	Japan	Bangladesh
Earthquake[3]	194	0	1,389	19
Flood[4]	13	52	7,573	317,631
Landslide	1	0	26	55
Storm[5]	35	635	7,863	77,385
Drought	-	1,900	-	25,002
Total	243	2,587	16,851	420,092

1.EM-DAT:The OFDA/CRED International Disaster Database
2.10 more killed/100 more affected/emergent declare/call international assistant
3.inc. TSUNAMI 4.inc. storm surge, coastal flood 5.inc. cyclone, typhoon, local one

With regard to every large-scale earthquake in Japan, the government has conducted examinations to clarify the characteristics of the earthquakes, estimate the damage and identify necessary countermeasures. The following set of plans and strategies for each large-scale earthquake are now being developed: “the Policy Framework”, a master plan that includes a range of activities from preventive measures to post-disaster response and recovery; the “Earthquake Disaster Reduction Strategy”, to determine an overarching goal of damage mitigation and strategic targets based on the damage estimation; and the “Guidelines for Emergency Response Activities”, which describes the action to be taken by related organizations (ibid).

Meanwhile, because of location of Bangladesh in a tectonically active area a strong earthquake could occur in the plate boundaries. Bangladesh is closed to the meeting point of the Indian, Eurasian and Burma (Myanmar) plates. Although large-scale earthquakes are reported only seven times during a century (Table 1), the meteorological department of Bangladesh detected at least 90 earthquakes taking place in the country between May 2007 and July 2008, nine of them above five on magnitude and epicenters of 95 percent being within a 600 km radius of Dhaka city (Ferdous and Pahman, 2010).

The earthquake record suggests that since 1900 more than 100 moderate to large earthquakes occurred in Bangladesh, out of which more than 65 events occurred after 1960. This brings to light an increased frequency of earthquakes in the last 50 years. This increase in earthquake activity is an indication of fresh tectonic activity or propagation of fractures from the adjacent seismic zones (Banglapedia Earthquake, 2013).

Moreover, it is these increased tremors that indicate the possibility of much more powerful earthquakes hitting the country. It is obvious that if a major earthquake hits Bangladesh it will create havoc and damages of life, properties that is unimaginable because of not only no awareness among the people but also poor preparedness by the government including lack of support facilities.

Now is the time to prepare to face the major earthquake disasters (Ferdous and Pahman, 2010).

Flood: Table 1 and Table 2 show flood frequency, number of deaths and sufferers of Bangladesh is 1.8, 4 and 45 times larger than that of Japan. Other EM-DAT indicates the frequency of unspecified and storm surge /coastal flood is same in the both countries and the number of general and flash type floods in Bangladesh is larger.

Main reasons of flood in Japan are meteorological conditions such as precipitation and active weather-front systems and geographical conditions such as precipitous terrains and steep rivers. One half of population is concentrated in possible inundation areas, which account for about 10% of the national area. Although there has been a large reduction in the area inundated by floods owing to soil conservation and flood control projects over many years, the amount of general assets damaged in flooded area has increased to 4 times of 20 years before. Additionally, as a long-term trend, there is an increasing tendency of downpours throughout the country. The number of last decade of heavy rains with precipitation of 100 mm or more per hour increased two fold of two decades ago (GoJ, 2002). The increasing trend of downpours in recent years requires the intensification of counter measures for quick and reliable evacuation and relief activities. The central disaster management council has been working on against flood disasters supposed to cause immense damage to the big town, especially capital region. In Japan, an urban flood that directly hits Tokyo area is a matter of special importance like such kind of earthquake.

On the other hand, the floods of Bangladesh indicate the area extent of flooding is gradually decreasing in the longer term and, at the same time, inter annual variability of the flood-affected areas has significantly increased since 1975: years with a low flood extent have become more frequent (Hoffer and Messerli, 2006).The failure of Flood Action Plan (FAP) to protect the country from floods has cleared the institutional assessment should examine practical means to overcome governance constraints and to increase local responsibility for managing flood protection and irrigation projects (Brammer, 2010). This means the government to be reformed and cooperate with people to protect the country.

Landslide: In Japan, there have been 21 major landslide disasters during the last one hundred years (Table 1) and if limited to post-war period up to 1995 it occurred 9 times and 149 persons were killed in total. Including large and small size ones 1,353 landslides occurred during 1990-1999 mainly caused by melted snow, seasonal rain (in the rainy season), typhoon, heavy rain etc. (GoJ, 2013).

Housing developments in mountainous and hilly areas have been extremely vulnerable to landslide disasters in more recent years. Additionally, as a long-term trend, there is an increasing tendency of downpours throughout the country. It is also a new residential area located on the edge of mountain that the landslide which caused by downpours and killed 74 persons in Hiroshima at the end of August 2014. On the back of such situation the governments of national and local authorities designate areas of active landslide movement or high risk areas of such movement as landslide threatened areas pursuant to the Landslide Prevention Law and conduct landslide surveys and prevention (control) works in these areas. Number of such designated area was 3,329 and 114,023 ha in 1999 (ibid.).

In Bangladesh, landslide disasters concentrate in south-eastern part of Bangladesh which is hilly and mountainous area. Although Table 1 shows only three landslide disasters in a century, Bangladesh Water Development Board (BWDB) reported Chittagong suffered about 12 times landslides during the last five decades. In recent years this disasters are more accelerated by human activities such as indiscriminate hill cutting for housing and brick field and deforestation etc. Consequently, by the devastation of this disaster the death toll is approximately 200 during these 12 years from 1999 to 2012 (Sarkar and Rashid, 2013).

Landslide is not listed in Table 2 and 3 as worst disaster in both countries. This is because the event is local and its damage is limited in one occurrence. Landslide events take place in remote and isolated area which is difficult to reach. The external helps may take several days to rescue the affected communities, especially in Bangladesh which has not enough communication roads. During their waiting period people of affected communities have to cope with their resources and arrangement. Therefore not only structural mitigation measures, legal enforcement of prohibiting uncontrolled hill cutting, enhancement of public awareness and so on but also community based risk reduction strategies such as equipment and distribution system of common resources, community-based early warning system, training for effective response etc.are also required (ibid.).

Storm: Frequencies of storms consisted chiefly of cyclone in Bangladesh and typhoon in Japan are more of the same (Table 1). Tropical stormsmake landfall easily in both of Japan surrounded by sea and Bangladesh facing sea. Especially, the low topography and funnel shaped coast line of Bangladesh makes the coastal associated with cyclones. 8.4% of the country can be area subject to high surge identified as the risk zone (RZ) upto which storm surge might travel inland. Within the area of RZ, 6.4% is the high risk zone (HRZ) where surge height may exceed 1m and people are likely to be killed from drowning (BUET-BIDS, 1993).

Although there is not much difference in frequencies, the number of fatalities and sufferers of Bangladesh are much larger than that of Japan. In the recent years, it is said the 1970 *Bhola* cyclone alone caused 500,000 (number is likely to be higher) death and the 1991 Bangladesh cyclone killed 150,000 people (Wikipedia Cyclone 2013).

In the 21st century, *Sidr* of 2007 and *Aila* of 2009 are two big cyclones struck Bangladesh. Particularly, *Sidr* was climatologically equal to cyclones of 1970 and 1991, nevertheless the death count was about 5,000. Such less casualties can be attributed to the Multipurpose Cyclone Shelter Programme (MCSP) followed by the construction of shelters and organized activities of Cyclone Preparedness Program (CPP) (Mallick and Rahman, 2013).

After the disastrous cyclone and storm surge which hit the coast on April 1991, Bangladesh government initiated the project searching the need for cyclone shelters with UNDP and the World Bank fund. Under the name of Multipurpose Cyclone Shelter Program (MCSP) it was reported that 2,500 cyclone shelters in HRZ would be needed in the year 2002 and 60% of the shelter were proposed to be located in existing primary school. In total, there are some 2,200 cyclone shelters at present in the coastal area while a total 4,000 shelters are considered as required to ensure the safety of the coastal population. Although the number of shelter is hardly adequate at the moment, there is almost no doubt that increasing shelters have been useful for the people to escape from disasters in these two decades.

The Cyclone Preparedness Program (CPP) is implemented by the government and Bangladesh Red Crescent Society (BDRCS) at administrative level. At the field level, the programme is implemented by the teams of volunteers in the minimum unit. Each unit serves 1 or 2 village with an approximately population of 2 to 3 thousand. 10 male and 2 female volunteers are recruited from the respective unit. In each unit, the 10 male volunteers are divided into 5 groups to discharge such responsibilities as to disseminate cyclone warning signals, to assist people in taking shelter, to rescue distressed people and to assist in relief and rehabilitation operations using provided equipment like siren, transistor radio etc. Two female volunteers of the unit provide first aid to the distressed women after the cyclone besides their task of raising awareness among the women folk in normal time. Historically speaking, the ideas of CPP started in 1965 and it has been developed to be marked by a favorable outcome (Harun-AL-Rashid, 1997).

In Japan "disaster countermeasure basic act" was enacted to develop comprehensive disaster prevention and administration in the aftermath of rare strong typhoon *Ise-wan* in 1959 (Table 3) (GoJ, 2002). Since then the government have aimed to establish the disaster prevention system which withstands super-typhoon like *Ise-wan*. Consequently, the damage of typhoon has decreased more definitely after the middle of twentieth century, which resulted from development of academic research works, advancement of weather forecast, institutional building based on experiences in administration, transmission of disaster records and voluntary organization among ordinary citizens. Nevertheless some areas of Japan get great damages and need to strengthen more safety measures. In a situation like that the government starts to formulate the action plan of "time line" which indicates countermeasures hour by hour in advance to reduce the damage in urban areas (NHK 2014). It is reported that the damage could be reduced because the subways had been stopped running one day before the occurrence of surge following "time line" in the United States when Hurricane Sandy attacked in 2012. Based on this Japanese government would request public transport to participate the discussion about time line action plan. The government is planning to compile countermeasures used for the action plan by this rainy season and it seems to take a few years at least to formulate the final action plan. Anyway, the idea of "time line action plan" can be worthwhile one for not only Japan but also Bangladesh.

Regarding the tornado, in Japan, 246 events (including small scale ones) have been observed during 18 years from 1991 to 2008 (JMA, 2013a). Most of them distributed along the coasts nationwide killing 12 and injuring about 600 persons (J.Wikipedia Tornadoes 2013). Although it was difficult to forecast incidents of tornadoes in past times, prediction accuracy has risen up to 20-44 % nowadays in Japan (JMA, 2013b).

According to the list of "86 tornados in Bengal for 1838-2001", 67 tornadoes struck Bangladesh of which 19 were reported to have caused deaths of 100 or more each while at least six incidents caused death of more than 500 people each (Finch 2013).

Thus the damage by tornadoes in Bangladesh is more serious than that of Japan. In the aftermath of two catastrophic disasters in 1989 and 1996 resulted in 1,300 and more than 700 fatalities respectively, the local neglected disaster of tornado in Bangladesh has attracted a great deal of attention from the world as severe local convective storms. In 2009 an international forum was held at Dhaka to discuss about counter measures of tornadoes. The approach to tornado mitigation is quite simple. Putting together an early warning system, structural strengthening of houses and the introduction of shelters on a domestic level (Mallick and Rahman, 2013). It is emphasized in the report of the forum that a community-based early warning system like CPP (IAWE 2009). In addition to build up the CPP-like organization by own experience Bangladesh can expect technological assistance for tornado forecast system from Japan.

Table 3. Worst 10 natural disasters in the two countries sorted by deaths

(1900-2013)[1,2]

Japan			Bangladesh		
Disaster	Date	Deaths	Disaster	Date	Deaths
Earthquake	09/1923	143000	Drought	1943	1900000
Earthquake	03/2011	19846	Epidemic	1918	393000
Earthquake	01/1995	5297	Storm	11/1970	300000
Earthquake	06/1948	5131	Storm	04/1991	138866
Storm	09/1959	5098	Storm	10/1942	61000
Storm	09/1917	4000	Storm	05/1965	36000
Storm	09/1945	3746	Flood	07/1974	28700
Earthquake	03/1933	3064	Storm	05/1963	22000
Storm	09/1934	3006	Storm	05/1985	15000
Storm	09/1923	3000	Storm	06/1965	12047

[1]EM-DAT: The OFDA/CRED International Disaster Daabase, [2]10 more killed/100 more affected/emergent declare/call international assistance, Earthquake includes tsunami, Flood includes storm surge, coastal flood, Storm includes cyclone, typhoon, local one.

Drought: Drought mainly caused by long period of dry weather is not a big problem in Japan because of abundant rainfall and forest coverage. Table 1, 2 and 3 show that the drought occurred only one time and very little number of deaths/sufferers during the last one hundred years. Drought, which had been known as one of main factors of agricultural damages in the past, was become to be controlled by water use-facilities made by the government with a large investment after the mid-*Meiji* era (Kaitani, 2013). And now it is said as a proverb that drought has no poor crop in Japan. Instead of drought which is not a big

problem in agricultural section, shortage of drinking and industrial water has become problems because of increased population in these days in Japan (Kotobank, 1998).

On the other hand, drought occurred 7 times and took a heavy toll of human lives in Bangladesh. Although table 3 shows 1,900 thousand people were killed in 1943 by drought, but it is doubtful that was caused by truly meteorological condition. One of famous historians wrote "famine of 1943 it was man-made disaster in that it was not a scarcity of food that caused so many to die but a collapse of the grain-marketing system (Shendel, 2009).

Drought mostly affects Bangladesh in pre-monsoon and post-monsoon periods to north-western region. From 1949 to 1979, the drought of 1957 which was one of the severest one affected 47% area of the country and the smallest drought in 1966 was 18%.To combat the drought, it is essential to utilize water resource for irrigation in Bangladesh like as Japan (Banglapedia, 2012). But it is a problem that they have to utilize surface water because of depletion of ground water resource as well as arsenic contamination. Surface water utilization projects such as barrages across the rivers, installation of pumping plants for lifting water from rivers are essential in Bangladesh (GoB. 2012)

Table 4. Natural Disasters in two countries (Economic damages)

1900-2013[1,2]

Disaster	Damage(billion $) (%)[6]	
	Japan	Bangladesh
Earthquake[3]	360(6)	0.5(1)
Flood[4]	12(0)	12(11)
Landslide	0.2(0)	-(-)
Storm[5]	57(1)	6(5)
Drought	-(-)	-(-)
Total	428.2(7)	19(17)

1.EM-DAT:The OFDA/CRED International Disaster Database
2.10 more killed/100 more affected/emergent declare/call international assistant
3.inc.TSUNAMI 4.inc.storm surge, coastal flood 5.inc. cyclone, typhoon, local one
6.Percentage of GDP(2011):Japan=5,867 Bangladesh=114 billion US$ (%)

Economic damages: Table 4 shows economic damages by five natural disasters and each number in parentheses shows percentage of economic damage to GDP in 2011 of each country. Table 5 lists worst natural disasters sorted by economic damages.

According to Table 4 amount of earthquake damage is the largest in Japan which is 6% of GDP. This can be understood by Table 5 which shows worst four damages are caused by the earthquake. The second largest damage is caused by storms and its amount is equal to one sixth of the damage by the earthquake. Damages caused by flood, landslide and drought are less than 1% of GDP.

Damage caused by flood is the largest in Bangladesh. Its equivalent amount of 12 billion US$ is 11% of GDP in Bangladesh and less than 1% in Japan. Second largest damage is caused by storms in Bangladesh and its amount is 5% of GDP. Totally, during the last hundred years,the amount of damage caused by natural disasters is 7% of GDP in Japan and 17% in Bangladesh.The amount of damage of Bangladesh is 2.4 times of Japan in the percentage of GDP although total real damage amount of Japan is 20 times larger than that of Bangladesh. The fact shows Bangladesh has not received bad influences at all economically, inferior to Japan.

Table 5. Worst 10 natural disasters in the two countries sorted by economic

1900-2013[1,2]

Japan			Bangladesh		
Disaster	Date	Damage (000 US$)	Disaster	Date	Damage (000 US$)
Earthquake	03/2011	210,000,000	Flood	07/1998	4,300,000
Earthquake	01/1995	100,000,000	Storm	11/2007	2,300,000
Earthquake	10/2004	28,000,000	Flood	06/2004	2,200,000
Earthquake	07/2007	12,500,000	Flood	06/1988	2,137,000
Storm	09/1991	10,000,000	Storm	04/1991	1,780,000
Storm	09/2004	9,000,000	Storm	05/1995	800,000
Flood	09/2000	7,440,000	Flood	08/1987	727,500
Storm	09/1999	5,000,000	Flood	07/1974	579,200
Storm	09/1990	4,000,000	Flood	09/2000	500,000
Storm	09/1998	3,000,000	Earthquake	12/2004	500,000

1.EM-DAT:The OFDA/CRED International Disaster Database
2.10 more killed/100 more affected/emergent declare/call international assistant
Earthquake includes TSUNAMI : Flood includes storm surge, coastal flood
Storm includes cyclone, typhoon, local one

Conclusion:

During the last hundred years, the storm and the earthquake occurred frequently and caused a lot of damages to human life and national economy in Japan. In contrast, the storm and the flood have been worst natural disasters in Bangladesh. Frequency of the storm in both countries are almost same but the number of deaths in Bangladesh are 18 times as much as that of Japan. Frequency and the deaths of flood in Bangladesh are larger than those of Japan although total amount of damage is equivalent. The economic damage of Bangladesh is 2.4 times of Japan in the percentage of GDP although total real damage amount of Japan is 20 times larger than that of Bangladesh. The fact shows Bangladesh has economically received bad influences not at all inferior to Japan.

Regarding Bangladesh, the disaster reduction policy of the present time has been made by the main stream of international ODAs and/or conferences. In the background of empowerment of women, community and the poor emphasized in the countermeasures, there were UN's millennium goals (2000), World Bank's poverty reduction strategy (2004), Hyogo (2005) and SAARC (2006) frame works for action. It can be said these agendas have connected the poverty and the disaster directly. Donor countries would request such kind of policy to the government as long as Bangladesh continues to be an aid receiver and she is obliged to meet expectation.

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J. Agrofor. Environ. 11 (1 & 2): 55-60, 2017 ISSN 1995-6983

An interdisciplinary study on existing land use and natural resource management in Klong Sathorn village, northeastern Thailand

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Abstract: This paper presents the results from interdisciplinary research project entitled "Existing Land Use and Socio-economics in KhaoPhuLuang-Wang NumKhieo Forest area: A case study on KlongSathorn Village, Northeastern Thailand". The project was interdisciplinary problem oriented and put the emphasis on participation of local communities and relevant institutions. Researchers from various disciplines including geographic information system (GIS), agriculture, forestry, environmental science, social science and economics worked together and closely cooperated with local people in the study area during late 2001 and early 2002. The outputs from the project have been used as teaching materials in the master program on Sustainable Land Use and Natural Resource Management at Kasetsart University (KU-SLUSE) and are expected to be useful to the relevant agencies.
Key words: Interdisciplinary study, GIS, land use, natural resource management, local community.

Introduction

In spite of a high economic growth rate during 1983-1989 problems of income distribution and rural poverty in the Thai economy remained (Punpiumrath, 1990). Sustainable development required alleviation of rural poverty. Most rural people were still poor and had to rely on natural resources to make their living. The main source of income was agriculture. Inappropriate land use resulted in natural resource degradation. Increasing the area of farm land via forest conversion and the application of agricultural technology had an adverse impact on the environment. Moreover, a lack of good farm management resulted in degradation in land as well as other natural resources. Examples included soil erosion, lower soil fertility, lower water quality and a poor water supply. Farm costs were higher while farm prices were lower leading to unsustainable development. In the eighth National Social and Economic Development Plan (1997-2001) the emphasis was upon an improved quality of life and better natural resource management. In the present plan (2002–2006) the focus is on economic recovery through a selfsufficient economy according to the Royal concepts. The targets were on poverty alleviation and uplifting life quality. The KhaoPhuLuang – Wang Nam Khieo Forest Area is an example of an area with problems of land use. Communities in this area were settled in the buffer zone adjacent to the Kao Yal national park. There are various types of land use including housing, agriculture and recreation. These activities have had an impact on natural resource abundance including forest, water, land, and the environment. Klong Sathorn Village was selected as a case study area and investigated in order to determine recommendations for sustainable land use and natural resource utilization. In order to support the national strategy on capacity building of human resource related to land use and natural resources management, an area base with the interdisciplinary approach was used as a guideline. The project was problem oriented and put the emphasis on participation of relevant stakeholders. Researchers from various disciplines worked together and closely cooperated with local community in the study area. The outputs of the project were used as teaching materials in the master program on Sustainable Land Use and Natural Resource Management at Kasetsart University (KU-SLUSE) and are expected to be useful to the relevant agencies.

The study attempts to gather basic information from a selected study site to compliment planning on sustainable land use and natural resource management. A geographical information system database will be developed. Problem identification and prioritization will be made and used in a further detailed study. Immediate objectives of this study are: (i) to collect and analyze data on physical and biological resources, (ii) to study livelihood of villagers living in buffer zone of the Kao Yai national park, and (iii) to identify and prioritize problems on land use and natural resource conservation and utilization of the community.

Materials and Methods

A preliminary survey was conducted in five sub-districts of Wang Nam Khieo district, Nakorn Ratchasima province, northeastern Thailand. Community leaders and relevant government agencies were interviewed. Basic information was collected. After analysis of the basic information, the team agreed to select Klong Sathorn village, Moo 5, Wang Hmee sub district to be the first study site with the objective to expand to other locations in further studies.

Klong Sathorn village, located in LumPhraPleung watershed was selected as a case study on land use and natural resources management at community level in the KhaoPhuLuang - Wang Nam Khieo forest area due to the reasons were as: (i) it is an agricultural land reform area, (ii) it is on the buffer zone of KhaoYai national park, (iii) there were immigrants coming into the area for agricultural land use, (iv) there are problems with water supplies, and (v) the community depends on forest resources.

Once the study site had been agreed upon, the researchers from each discipline collaborated in determining the research framework (Fig. 1) and developed a structured questionnaire for the village's household survey. A number of 127 samples households from the total of 133 households in the village as reported in GorShorShor 2 Kor (Department of Community Development, 2001) was interviewed. Overall picture of households including household structure, land tenure, income, living expenses, agricultural practice, and community problems was

investigated during November 2001 to May 2002. Information from the surveywas employed for further detailed or in-depth study in each discipline as:

Geographical Information System: Spatial, non-spatial (attribute) and other data were collected from the maps of various institutions. Interpretation of remote sensing imagery and field survey using GPS wereconducted. The ARCVIEW and PC ARC/INFO were used for establishment of data base system. The data were classified and grouped following data dictionary made. The baseline data helped to facilitate efficiency among the researcher in each discipline.

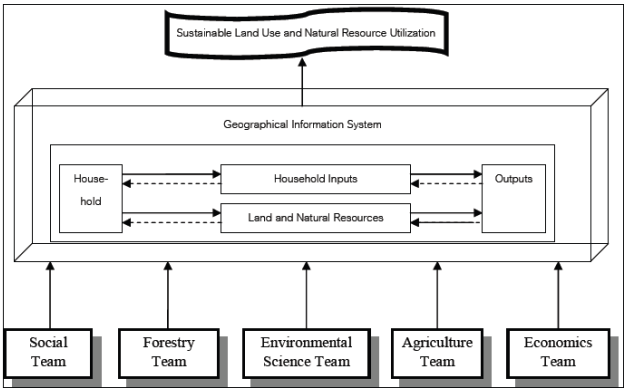

Figure 1.Conceptual framework.

Agriculture: Team together with the economic team selected 37 farm households from the 127 in the previous household survey. A questionnaire for in-depth interview was developed. The selected households were interviewed. The study covered preparation of data on cropping and agricultural land use. Constraints in land use were identified

Forestry: Team conducted preliminary survey of the community. 92 sample households from the 127 households were selected to study the relationship between forest and villager's livelihood usinga structured interview. Forest dependency and potential on farm forest development were investigated using rapid rural appraisal (RRA) techniques e.g. direct observation, mapping, etc..Group discussions were organized to wrap up the findings.

Environmental Science: Team collected and analyzed data on weather, hydrology, geology, water quantity and quality; they surveyed plants and animals in a community forest near by the village.

Social: Team conducted a social survey on 127 households and conducted semi-structured interviews with key informants including local officials and community leaders, in-depth interviews, nonparticipatoryobservation, a historical study, geographical ground survey, community mappingand topographic modeling.

Economics: Team collected secondary data about the study site and assessed the economic conditions from RRA, interviewing local officials and community leaders. General data from the 127 household surveys were analyzed. The analysis of farm household was conducted from the in-depth interviews with 37 farm households, in collaboration with the agricultural team. The analysis covered household structure, land tenure, revenues, living costs, debts, agricultural problems,farm costs and returns, and economic problem of land use.During the completion report preparation, research teams collaborated in organizing acommunity meeting to present their findings to the community and relevant agencies in the area,as well as to brainstorm for feed back to the problems identified. Together, the research teams compiled research results and integrated problems of land use and natural resource management in KlongSathorn village; synthesized the issues; and analyzed their causes, effects and inter relation.

Results and Discussion

The findings of each study team were elaborated in the six final reports (Durongdet *et al*., 2002; Jintana *et al*., 2002; Narangajavana *et al*., 2002; Saksoong *et al*., 2002; Srijantr, *et al*., 2002 and Tongpan *et al*., 2002).

The advantage of GIS technology for contributing towards natural resourcemanagement is related with the spatial extent of the area. In this study, the general informationwas separated into three levels as shown in Fig. 2. The first was the basic information at thewatershed level, which consisted of province, district and sub-district, in map A, such as WangNam Khieo district. The second was the sub-watershed level, which consisted of many villages, in map B, such as Lam PhraPhloeng 1 catchment area. The third was in the community level,which consisted of one village (many households), in map C, such as KlongSathorn village.

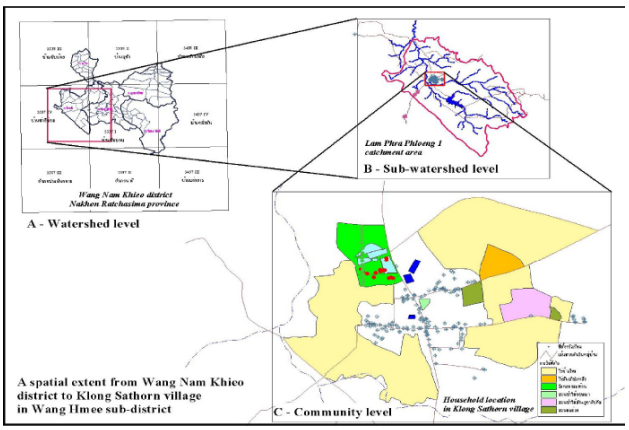

Figure 2. A level of information related with a spatial extent.

Most of the land in KlongSathorn village is located in an agricultural reform area, the degraded forest area which the government allocated for farming. Nevertheless, according to this study there were land use problems that led to the farmers' inability to keep theirfarmland. Low farm income, inappropriate agricultural systems, weak community organization, and dependency on forest resources were found to be the major problems relevant toun sustainable land use in the village. The following results give a synthesis of the problems asobserved by each discipline. Important problems are considered together with their causes and effects as well as their interrelation. Solutions to the problems are recommended. The synthesisis conducted as indicated in the diagram showing the relations of problems of land use andnatural resource management in KlongSathorn village (Fig. 3).

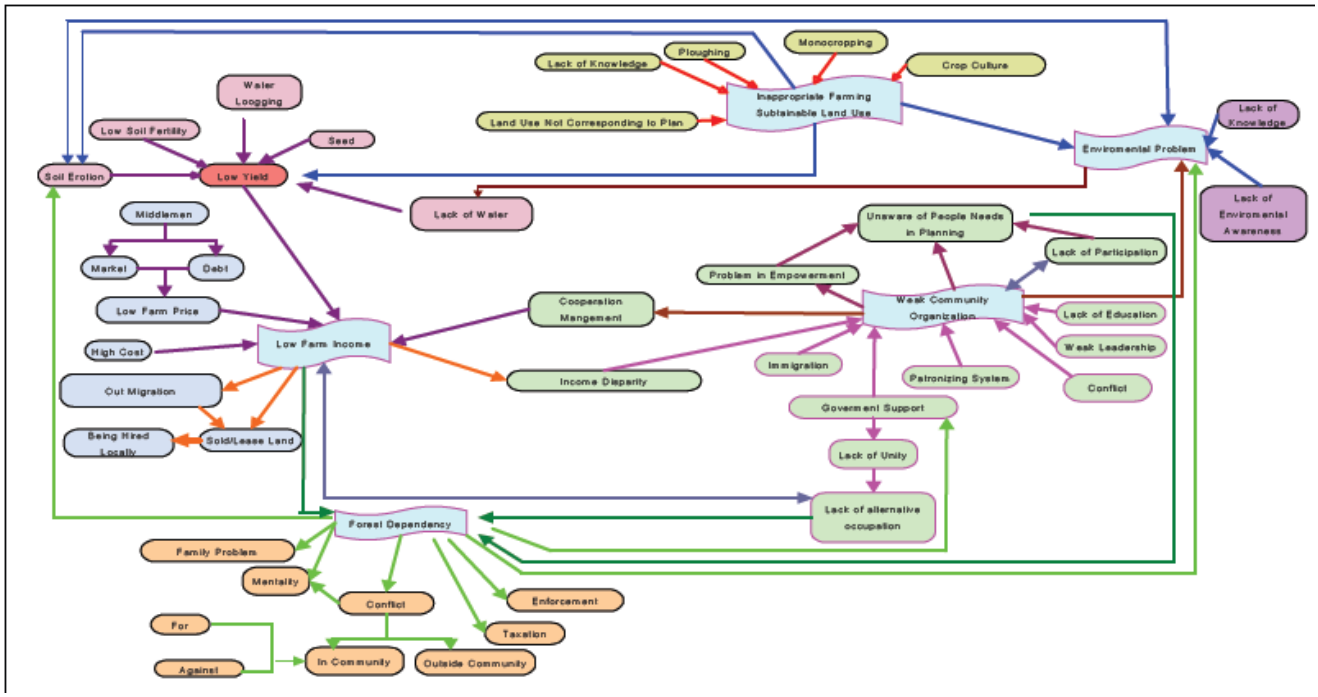

Figure 3. The relations of problems on land use and natural resource utilization in KlongSathorn village

Inappropriate farming systems: Most of the farmland was upland. None of the field areas were irrigated. The soil types weremainly sandy and loamy sand with a clay layer at a depth of 50-70 cm (Anurakpongsathorn, 1996). The rain absorbed underground accumulated over the clay strata. Farmland was obstructed by road and farm dikes, this resulted in water logging. Heavy rainfall induced water logging which resulted in growth and yield of fruit trees and other perennial crops.

Usually the cultivated land was left uncovered during the dry season. Farmers ploughed along the slope. Heavy rain during the early cropping season led to washing and erosion of top soils, thus reducing soil organic matter. Soil erosion caused increasing of sediments in natural water sources and reservoirs. Artificial ponds and reservoirs of the households became shallow within a short period. Though KlongSathorn village locates close to a reservoir namely LamPhraPhloeng 1 but the villagers could not obtain water for farming. The reservoir was constructed mainly for trapping sediments and no irrigation canal was available. Cultivation of maize and other crops was reliant upon rainfall. In the case of drought or a long dry season, those crops would be damaged.

In KlongSathorn villag, rice was grown for household consumption. Limiting ofland, the rice planting area was small. Maize was the main cash crop. Most villagers grew maize once a year and repeated cultivation on same land for a long time. Such practices led to ahigh risk of disease and pest spreading. They had to apply more chemicals to get rid of diseases and to control pests, leading to negative impacts on the environment e.g. water quality. A lack of household's labour increased the number of hired labours, thus farm costs increased. Though the yield and price of maize was relatively low, villagers were bound to grow maize. Due tolack of investment funds, farmers relied on middlemen who advanced seeds, pesticides and chemical fertilizers for growing. After the harvest, they had to sell maize to merchants whowere their lenders, thus they did not have any bargaining power. This practice continually onthe same land without any soil maintenance and resulted in soil erosion and low soil fertility e.g. phosphorous and potassium contents were found particularly low. Farmers had to increase the application of fertilizers year by year to maintain crop yields. Slashing and burning of crop remains and weeds before ploughing occurred and this was mismanagement as it led to soil degradation and lower soil fertility. Ploughing and growing maize up and down the direction of slope resulted in increasing soil erosion and rapidly decreasing soil fertility.

Inappropriate agriculture, mono-cropping system had a high risk of a low price forfarm production and of causing environmental deterioration. Multiple cropping and integrated farming including livestock could recycle farm resources. Farmers would be less dependent oninputs from non-farm sources. In spite of a smaller cash income from the products and more complications in marketing their produces, multiple and integrated farming could yield a better overall income, in cash and in kind. These methods also reduced the risk from lower prices and environmental damage. Villagers would have more agricultural activities, thus reducing out migration to the non-agricultural sector as well as outside the village. Growing a main crop followed by a marketable short-lived nut crop would increase farm income and on the other hand increase soil fertility.

Forest dependency: Klong Sathorn villagers had been long accustomed to gathering forest products from KhaoYai national park both for household consumption and for sale, especially among the first settlers.Economic and social land development via commercial agriculture or mono-cropping did notlessen the necessity of the villagers'

forest dependence. This led to problems in natural resource management through the years.

Being adjacent to KhaoYai national park, the villagers were familiar with theutilization of forest products for their living, for commercial, and for recreation purposes. While waiting for the maize harvest, they looked for work outside the community. If they could notget any job, they would go back into the village and gather forest products to make their living. Allocating land for agriculture did not lessen forest dependence. A number of farmers sold their land to wealthier people who had access to better social opportunities. These landless farmers turned to rely on forest resources for their survival. It is a burden for the government to monitorand capture those violating the Royal Decree on National Parks B.E. 2504 (1961). Some illegal forest product gathering had negative impacts upon biodiversity in the area, e.g. cutting agar wood trees and hunting. This became a social indirect tax as the number of government forest guards had to be increased. When violators of the law were captured they could be jailed which might cause family problems and adverse impacts upon the family. For example, when thefather was jailed, the family leader could not earn income for they family and children might beunable to attend school.

At the same time, there was conflict in the village since some villagers did not agreewith illegal forest products collection in the national park as some government agencies couldcut their assistance for community development. On the other side those violators lacked alternative job opportunities, especially among those landless and hired farm workers who were unemployed when the maize cropping and harvesting season was over. A lack of understanding between the villagers who had to rely on forest products and the priest who tried hard to increase public awareness on resource renewal (including timber products from agar wood and *Hopea*, and a calm natural scene) for the community was clearly observed. Studies in many areas have indicated that dependence on natural resources wasrelated to the size of land holding and income. Social and economic conditions had clear impacts on the intensity of natural resource dependence (Beer and McDermott, 1996). Fromthis study it was also found that the volume of household forest product gathering was inversely related to size of land holding and income. Households gathering more forest products were those with small land holdings or without farmland and low income households. Due to a lackof alternative job opportunities, some farmers changed to earn income from illegal forest product gathering in the national park. It was noticed that the first settlers insisted on utilization of forest from the national park which could be explained by their usual practice as well as their culture.

Promotion of resource renewal for the villagers' own utilization, e.g. domestication of wild species and agro-forestry could reduce forest degradation. Government and relevant agencies could offer support and assistance for organizing an agroforest group among those interested, and recommend appropriate integrated land use and natural resource utilization from production through to utilization and marketing. The target should be on sustainable local ecosystems and uplifting the community's social and economic status. Development of alternative job opportunities for better income among households with limited or withoutfarmland could decrease destructive forest dependency. For example, the community should participate in ecotourism in the national park and in forest co-management in the protected area including forest fire control, protection and rehabilitation of the forest.

Environmental problems: Villagers in Klong Sathorn migrated from diverse locations including the upper central andnorth-eastern provinces. Struggling for survival led to a lack of interest in environment and natural resource conservation. Most of these villagers did not adequately realize the importance of environment relevance their life quality. Moreover, a weak local organization made collaboration difficult on community activities. Natural resource utilization was forced byforces from outside the community.

Besides being located in a low rainfall area, the change from forest into agricultural land had an impact on the soil properties, the quality of topsoil which used to be abundant in organic matter and had good water absorption changed. According to the GIS, the area wassloping with underlying laterite clay which had a limited capacity to retain rain water for agriculture. Runoff quickly flowed into streams. Agricultural land lacked sufficient water resulting in low yields. The hydrological potential of agriculture in KlongSathorn village was low.

Weak community organization: An important social problem in KlongSathorn village was a weak community organization. The causes of this problem diverted including of settlement, the patronage system, improper government support, weak community leadership, limit of knowledge as well as education among the villagers, and income disparity resulting in different social status. Villagers migrated from various areas at different time and were of different a status. The background of the villagers was varied, thus it was difficult to collaborate and establish a strong community organization. There was a patronage system within groups of villagers. Groups were numerous. The patronage system constrained co-operation in the overall community, and limited efficient collaboration. Different social status and income disparities among the villagers were found also to be a cause of failure in community collaboration.

The villagers were not highly educated. They had to work hard to make their living, thus they could not participate regularly in collective activities. A weak leadership and a lack of absolute decision making resulted in an inability to develop strong community organization.

Government support which did not accommodate community needs alsoled to conflict in the community due to inequities in getting support. This was another cause of community organization weakness. Government planning which did not take in to account the needs of the community, local empowerment where the community had not been ready to take charge of administration and management, aswell as a village development project which was politically oriented resulted ingovernment support being a constraint on the building capacity for community organization in KlongSathorn village. The

effects of weak community organization resulted in problems inempowerment and lack of local participation which resulted in planning which couldnot accommodate local needs. These were obstacles for community development. A lack of participation led to an inability to develop community organization.Weak community organization resulted in inefficient extension of job opportunities, adverse impacts on household income and living conditions, forest dependency, and environmental conditions since there was natural resource extractionbut lack of proper management.

Low farm income: The most important economic problem of land use in KlongSathorn village was low farm incomes. This problem was related to two other economic problems i.e. income disparity and a lack of alternative job opportunities. These problems were also related to other non-economic problems.

Low yields, high costs of production, and low farm price were the causesof low farm incomes. Inappropriate farming, an agricultural problem, was the causeof low yields and high costs. Weak community organization, a social problem, resulted in low income. Weak community organization also led to management problem in agricultural co-operation and a lack of alternative job opportunities which were the other two causes of the problem on low income. The impacts from low income were household income disparity, land leasing and/or selling land, working outside the community. A lack of local job opportunities was both a cause and effect of low income.

Besides low yield, a low farm price was another cause of low farmincome. Villagers were bound, being indebt, to sell their harvests to a limited number of buyers. Their market opportunity was restricted. A high cost of production was another factor of low farm income. Villagers had to pay high interest on their farm loans in terms of lower farm prices. They had to apply chemical fertilizers. These were the results of inappropriate farm practices. Lack of efficient agricultural cooperation was another factor of low farm income leading to the inability in input procurement, lack of market opportunity, and lack of bargaining power. Inefficient agricultural co-operation was a result of weak community organization which was asocial problem of KlongSathorn.

Other social impacts of low income were improper government intervention and a lack of unity in the community. Some government interventions such as the Village Fund which was introduced into the village while community organization was still weak led to conflict among villagers. Diversity among villagers constrained collaboration of economic activities which could provide villagers alternative sources of income. Due to a lack of local job opportunities, villagers hadto rely on farming. They selected crops according to the middlemen's demands. The main crop was maize which earned low income. Lack of alternative job opportunities was also a result of low income. Poverty made it unaffordable for householders to invest in a better occupation. Inspite of the existence of higher earning jobs, the farmers did not have access to investin such opportunities.

Due to low farm income, some farmers leased or sold their land. Leasing land earned an assured income. Farmers did not have to take risk in cropping. Nevertheless there were small farmers whose income from leasing or selling their land (or land rights) could not cover their living costs. These farmers became hired workers, and so changed their social status. Due to low incomes in KlongSathorn, some capable family member chose to work outside the community earning higher incomes. Currently some households in the village relied on income sent to them by their family members who worked outside the village. Such behaviour reflected unsustainable land use. Local people had to leave home to work in the other areas to secure their income.

Furthermore, low farm income resulted in income disparity between former settlers and new comers. Low income households were usually farm households. Some households sold their land and turned to be hired farm workers.

New settlers, when transportation was more convenient, were usually richer, beingcapable of earning higher incomes than those who previously lived in the community.

Their incomes were different. Income disparity resulted in difficult collaboration among these villagers. There was social conflict, thus weak community organization. Low income in KlongSathorn village was the main economic problem. It was a result of inappropriate agricultural systems, the main agricultural problem, andweak community organization, the main social problem. Causes of low income were low farm prices, high costs, low yields, inefficient agricultural co-operation, and lack of alternative local job opportunities.

Low farm price was a marketing problem, the farmers were bound to their middlemen. To solve this problem, there should be a search for new market opportunities and releasing farmers' debt burden with the middlemen. New market opportunities may be possible if the community could collaborate to perform economic activities. Nevertheless, weak community organization was a hindrance tosuch opportunities. High costs and low yields resulted from inappropriate agricultural practices. Recommendations for appropriate agricultural systems are a key toreducing the problem. Inefficient co-operative management and a lack of alternative job opportunities were results of weak community organization which was a social problem.

Solutions to low income are to find higher earning job opportunities locally. Recommended alternatives are agar wood forest gardening, rattan processing, and ecotourism. There was a need to strengthen the community organization as wellas correcting the problems in agricultural co-operative management to increase the bargaining power and economic opportunities. Agricultural practices should be improved using appropriate farm technologies in correspondence with location, market and profitability.

Conclusions and Recommendations

Results of the study reflect unsustainable land use in KolngSathorn village. Low incomes, especially farm incomes, resulted from inappropriate farming leading to

low yields and high costs. Weak community organization was the other cause of low incomes. Farmers had to farm as demanded by the middlemen. Low incomes andpoverty increased forest dependency and natural resource utilization, a tendency tonegative environmental impact. KlongSathorn village is a case study elaborating unsustainable development. In spite of government allocation of land, farmers couldnot maintain their land. They sold land rights to those who were wealthier and became hired workers or moved to work in other areas.

Integrated farming in place of mono-cropping (which was maize according to the middlemen's demands) is one of the solutions to low farm incomes. Nevertheless, cultivating alternative crops requires investment funds and market opportunities. Better transportation provides market opportunities for farmers from Klong Sathorn village. They have the opportunity to deliver their merchandise tonearby markets. There are several markets i.e. at Pak Chong and Wang Nam Khieo districts which are whole sale markets. To deliver merchandise to such markets, theymust gather an adequate large volume to cover transportation costs. If the villagers can collaborate for such economic activities, market opportunities can be developed.

Problems of indebtedness and a lack of investment funds should be alleviated. Actually, there are various funds available in KlongSathorn village, e.g.the Village Fund, the Economic Community Fund, and the Agricultural Development Fund which ware allocated by the government. Due to weak community organization, management of these funds has not been adequately efficient. If these problems could be lessened, these funds could be available to reduce the debt burden and for investment for better earning economic activities.

Strengthening the capability of community organization is an immediate solution. The diversity of community members, variety of immigration from differentlocations, times and status make collaboration difficult. Nevertheless, from the reportof the social team, there was social interaction among nearby neighbours andrelatives. They regularly got together for social events. This collaboration was within different settler groups. Collaboration can be initiated at this level. Government should take a coordinating role and provide villagers with the necessary infrastructureas the starting point for collaboration among such groups. Strengthening community organization will increase awareness on the values of natural resources and environment since group ownership is more valid than individual ownership. This will lead to alleviating environmental problems and maintain forest resources for sustainable utilization.

Appropriate agricultural systems, extension services for local job opportunities, building up opportunities in income generation, and adding value tovillage products will increase the income and thus quality of life in correspondence tothe improved infrastructure. These will lessen the problems of selling land rights, thus maintain villagers in the area, to protect their land and natural resources.

Acknowledgements: This research was financially supported by DANCED via Thai University Consortium on Environment and Development - Sustainable Land Use and Natural Resource Management (TUCED-SLUSE) and Kasetsart University Research and Development Institute (KURDI). Kyoto University, Japan supported the trip to Myanmar for presenting this paper. The authors would like to thank them all.

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J. Agrofor. Environ. 11 (1 & 2): 61-66, 2017 ISSN 1995-6983

Dynamics of agroecosystems in the Brahmaputra valley, Assam (India)

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Abstract: Agro ecosystems have been created and modified by the people to satisfy their demand for food, fiber, fuel and other products. The nature and degree of modification, however, vary over space and time depending upon the environment, need and aspirations of the people living in different parts of the world. The changes that take place in the human environment make the associated agroecosystems more dynamic resulting in remarkable transformations in the agricultural landscapes. This work attempts to study the pattern of change in the agroecosystems of the Brahmaputra valley, Assam from geographical perspectives. It focuses on the evolution of agroecosystems and the factors responsible for making them increasingly dynamic in the changing contexts of nature-culture interaction. Special attention has been paid to the dynamics of area and output of rice, which continues to be the dominant crop in the agroecosystems within the valley.
Key words: Dynamics, agroecosystems, Brahmaputra valley, Assam, India.

Introduction

The Brahmaputra valley, a major physiographic unit of Assam, is endowed with rich natural diversity and varied cultural manifestations. The physical and social peculiarities of this river valley have helped development of characteristic agroecosystems within it. The Brahmaputra valley has long been under traditional land use practices dominated by food grain and cash crop farming, fisheries, traditional homestead gardening etc., which make the valley's agroecosystem diverse. The traditional land use practices adopted by the farmers belonging to different communities have their roots in the community cultures in a given ecological setting, which contribute immensely to the sustainability of the valley's agroecosystems. However, during the recent period, the diversity and sustainability of the valley's agroecosystems have been considerably disturbed by the processes of rapid development of the agricultural sector including extension of modern irrigated agriculture, application of chemical fertilizer, High Yielding Variety (HYV) seeds, exploitation of ground water, alteration of land use and cropping pattern and expansion of infrastructural facilities. In addition, the demographic instability, socio-economic changes, changing attitude and perception of the people and farmers, government policies and efforts of the Non Government Organizations (NGOs) have been simultaneously contributing to the dynamism of the valley's agricultural scenario.

The change in the agroecosystems from the traditional to modern may eventually endanger the very sustainability of the long-continued, reliable and, in many cases, eco-friendly agroecosystems of the valley. The present paper is therefore an attempt to investigate the nature and trend of change in the agroecosystems of the valley so as to evolve strategies towards bringing about a positive and sustainable change in the systems.

The Brahmaputra valley covering an area of 56,194 sq. km (72 % of the state's total geographical area) with an east-west span of about 720 km and an average width of 80 km is a unique physiographic entity of the state of Assam **(**Fig. 1**)**. The river Brahmaputra with its 32 major tributaries has been playing a great role on the valley's agroecosystems primarily by supplying huge amount of alluvium to its floodplain. The valley comprises of the elongated north and south bank foothill belts, extensive built-up plains and active floodplains including the most sensitive sandbars (*charlands*). The varied micro-physiographic features and climatic conditions and the rich biological diversity combined with socio-economic multiplicity have contributed remarkably towards variation in the pattern and processes of agricultural land utilization in the Brahmaputra valley (Bhagabati, 1990a; 1990b).

The agroecosystems of the Brahmaputra valley are basically dependent on the seasonal rhythm of monsoonal downpour. The average annual rainfall in the valley is 230 cm, while the Himalayan sector of its catchment records more than 500 cm. The soils of the valley are mainly composed of alluvium and piedmont deposits. The valley has rich diversity of flora and fauna. The total forest area of the valley in 2001-02 was 1.29 million hectares accounting for 23.02 % of the valley's total geographical area.

Human history started in the valley long before the Aryan civilization some five to seven thousand years ago which spread eastward along the Brahmaputra valley (Choudhury, 2004). The Brahmaputra valley has been inhabited by people of diverse ethnic and socio-economic backgrounds. The valley, accounting for 72 % of the state's total area, shares 85**.**00 % of the total population of the state. The density of population in the valley according to 2001 census was 407 persons per sp.km.

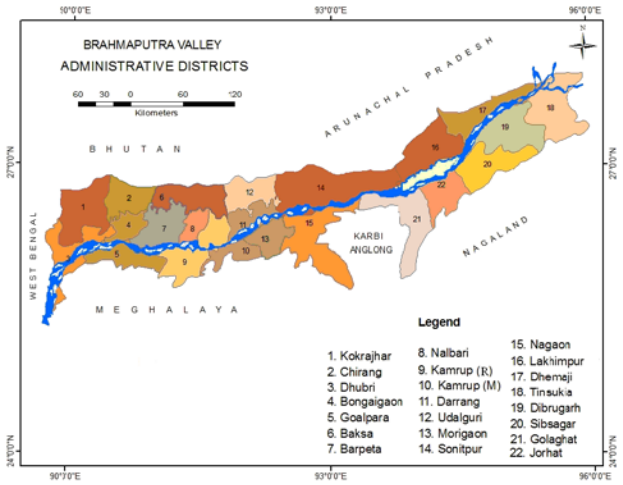

Fig. 1. Brahmaputra Valley Administrative Districts

Materials and Methods

The Brahmaputra valley, which represents a broad agroecosystem zone within the state of Assam, has been selected to investigate the dynamism and sustainability of its diversified agroecosystems. The agroecological

conditions of the valley have been studied on the basis of direct field experiences, surveys through well-designed schedule, secondary data collected, consultation of maps and books and journals. Required base materials for the study have been collected /generated from sources like Survey of India's toposheets with scale 1:50,000, satellite images, revenue maps etc. Relevant literatures were reviewed to develop necessary conceptual framework and appropriate methodology to carry out the work from right perspectives.

Relevant secondary data on agroecosystems of the Brahmaputra valley have been acquired from government sources like the Directorate of Agriculture, Department of Water Resource Development, Meteorological Centre, Directorate of Census, Department of Soil Conservation, Assam Agricultural University etc. Meaningful quantitative and cartographic techniques and soft wares (Arc GIS 9.2, MS Excel, SPSS etc.) are applied to process and represent the data in the form of maps and diagrams. Efforts are made to analyse the problem following certain concepts and models available in the field of agroecosystem studies so that the issues with respect to individual components and the overall agro ecosystems can be understood properly.

Results and Discussion

Evolution of agroecosystem in the Brahmaputra valley: The agroecosystems in the Brahmaputra valley have been evolved since the beginning of human habitation. The state of agriculture in the Brahmaputra valley has been changing from tribalism to feudalism and then from feudalism to the modernism of agriculture (Nath, 2002). The valley was inhabited by the people belonging to indigenous tribal and non-tribal groups like Khasi, Moran, Barahi, Bodo, Karbi, Mishing, Tiwa, Dimasa, Chutia and Bhuyan who entered into the valley through the river valleys and mountain passes from the neighbouring countries and other states of India. Other racial groups like Ahoms and some Tibeto-Burmans and Aryans penetrated into the valley in subsequent periods. These racial groups, with their distinctive cultural backgrounds and traditional knowledge systems gradually started cultivating the land in the Brahmaputra valley (Das, 2004; Choudhury, 1987).

The ancient people, whether following Aryanised or tribals habits, practiced rice cultivation in the valley as rice was their staple food (Barpujari, 2004). The Garo and the Bodo-Kachari tribes in the lower Brahmaputra valley practiced *ahu* and *bao* rice cultivation by using hoe and traditional irrigation system. The Chutiyas, the earliest tribes inhabiting the upper Brahmaputra valley districts, used to practice wet rice cultivation. The Bhuyans reclaimed new lands of the valley and put them under cultivation. The migration of Ahoms into Assam had made significant contribution to the agrarian life and culture of the state during and after the 13th century by introducing new agricultural inputs and implements. The Ahoms acquired ecological and agricultural knowledge and belief systems from the local tribes and castes of the valley such as the Bodos, Kacharis, Chutiyas and the Bhuyans. The Ahoms had brought large areas of the valley under permanent rice fields, gardens and orchards. The Ahom rulers had also given importance to each land cover type like marshy land, forest, *beel* or pond and waste land as potential productive lands.

Evolution of cultivation method and agricultural technology: The technologies used in the agricultural operation in the Brahmaputra valley were of the archaic type. Most of the tribes of the state had traditionally used some sorts of agricultural technology like hoe and stick in the agricultural operation. The Ahoms in the early thirteenth century introduced the advanced plough and other agricultural inputs and implements. They with their skills making earthen bunds raised numerous embankments locally called *mathauri* along the tributaries of the Brahmaputra. Thus, over time the scenario of agroecosystems of the Brahmaputra valley had undergone radical transformation. The traditional agricultural implements used in the medieval period in the valley were wooden plough (*nangal*) with an iron tipped share (*phal*), wooden rakes (*jabaka*) and mallets (*dolimari*), harrow (*mai*), yoke (*juwali*), sickles (*kachi*), bill hooks (*da*), knives (*churi-katari*) and variety of bamboo baskets like *duli*, *mer*, *kharahi*, *pachi*, etc. (Nath, 2002).

It is noteworthy that there has not been any perceptible change in the nature of use of the traditionally developed agricultural implements even during the British period in the early part of the 19th century. The methods of transplanting, ploughing and harrowing, hoeing and sticking, threshing, preserving seeds, applying organic manure and pesticides, making of dykes etc. are carried out even today almost in the same style or with little modification. However, some new dimension have been added to the valley's agricultural landscape with the introduction of modern agricultural inputs and implements like HYV seeds, chemical fertilizers and pesticides, power tillers and threshers, sprayers etc, during and after 1980s (Deka and Bhagabati, 2010).

Nature and pattern of change: The agroecosystem in the Brahmaputra valley has been changing both qualitatively and quantitatively over time and across space due to the nature and degree of modification made by the people. With the rapid growth of population, growing needs for foods and introduction of modern agricultural technologies, the valley's agroecosystem witnessed perceptible changes. The traditional system of farming in the valley is in the process of transformation into the modern phase. The diversity and long-term sustainability of the valley's traditionally developed agroecosystems have been gradually giving ways to the process of modernization. After the introduction of modern agricultural inputs and technologies, the production, yield and the area under crops have been increasing.

Change in area, production and yield of different crops: It has been observed that the crops in the valley have undergone considerable change both in terms of their cultivated area and production due to shrinkage of agricultural lands, transfer of agricultural land to non-agricultural uses, mono-cropping of HYV crops, lack of sufficient irrigation and application of modern inputs and machines. It has been found that the area and production of cereals, oilseeds, pulses and horticultural crops in the

Brahmaputra valley had declined during 2001-2006. The area under pulses registered a decrease by 53.96 % followed by oilseeds (27.15 %), horticultural crops (10.23%) and cereals (10.03%) **(**Table 1 and Fig. 2).

Table 1. Change in area under crops in the Brahmaputra valley, 2001- 2006

Year	Area (in ha) under crops and their % change during 2001-2006			
	Cereals	Oilseeds	Pulses	Horticultural crops
2001-02	2253088	281345	191869	128484
2005-06	2027084	204956	88336	115337
% change during 2001-2006	-10.03	-27.15	-53.96	-10.23

Data source: Directorate of Agriculture, Government of Assam

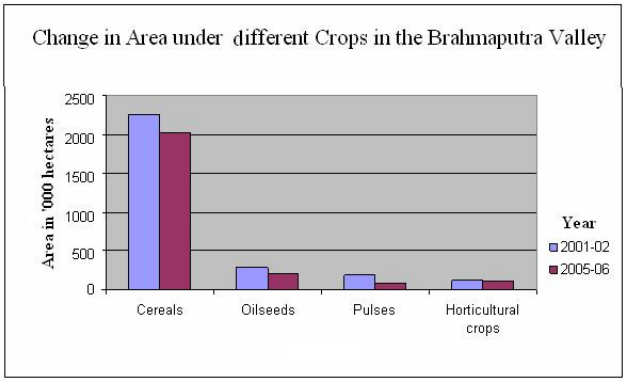

Fig. 2 Change in Area under different Crops in the Brahmaputra valley, 2001-2006

Similarly, with the decrease of area the production of cereals, oilseeds, pulses and horticultural crops in the Brahmaputra valley has also been declining. The decline in the production of these crops may also be ascribed to the traditional mode of cultivation, use of local varieties and erratic nature of rainfall. The production of pulses registered a decline by 55.03 % followed by oilseeds (29.25%), cereals (11.36%) and horticultural crops (9.31%) **(Table 2 and Fig. 3)**.

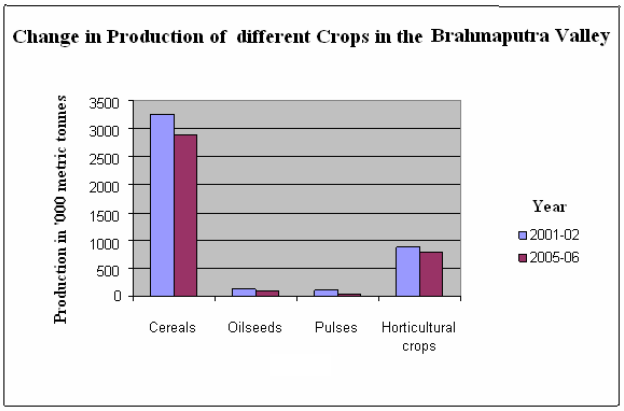

Fig. 3. Change in Production of different Crops in the Brahmaputra valley, 2001-2006

Table 2. Change in production of different crops in the Brahmaputra valley, 2001-2006

Year	Production (in metric tones) of different crops and their % change during 2001-2006			
	Cereals	Oilseeds	Pulses	Horticultural crops
2001-02	3248701	139824	105674	870441
2005-06	2879711	98925	47523	789367
% change during 2001-2006	-11.36	-29.25	-55.03	-9.31

Data source: Directorate of Agriculture, Government of Assam

Table 3. Change in area under different types of rice in the Brahmaputra valley during 1960-2005

Year	Area under rice (in hectare) and percentage change							
	Autumn rice	Change %	Winter rice	Change %	Summer rice	Change %	Total rice	Change %
1960	314577		1092238		2448		1409262	
1965	402149	27.84	1138786	4.26	10709	337.49	1551644	10.10
1970	527880	31.26	1220830	7.20	12360	15.42	1703870	9.81
1975	636800	20.63	1204800	-1.31	25830	108.98	1777490	4.32
1980	606225	-4.80	1245570	3.38	26420	2.28	1788010	0.59
1985	640600	5.67	0	0	31766	20.23	1950914	9.11
1990	608150	-5.07	1374653	0	102866	223.82	2008756	2.96
1995	624761	2.73	1323074	-3.75	140958	37.03	2028731	0.99
2000	539665	-13.62	1344888	1.65	310624	120.37	2134261	5.20
2005	359693	-33.35	1105894	-17.77	260729	-16.06	1671562	-21.68

It has been revealed that the area under rice has been gradually increasing registering a change of + 51.45 % during the period 1960 - 2000 (Table 3). The area under rice after every five years from 1960 to 2000 has shown positive change, except in the year 2005. There was a severe drought in 2005 for which rice area declined. The area under different types of rice (autumn and winter rice) has also witnessed considerable changes (both positive and negative) in the subsequent periods. However, the area under summer rice has been continuously increasing except for the year 2005. It is because of the fact that the farmers of the Brahmaputra valley, especially those from the *char-chapori* areas have opted for cultivating summer rice as an alternative to autumn and winter rice as these are regularly affected by floods and droughts. The area under rice is, however, fluctuating depending mainly on the availability of rainfall and extension of cultivation to some new areas.

The productivity of rice in the valley has also been increasing. The yield as calculated at five years interval from 1960 to 2005 shows positive change except for the year 2005 (Table 4). The productivity of rice during 1960 - 2000 registered a change of + 70.31 %. The production of rice in 1960 was 1.28 million tonnes which increased to 3.99 million tonnes in 2000, registering a change of + 211.72% during the period (Table 5).

Table 4. Trend of yield of different types of rice in the Brahmaputra valley during 1960-2005

Year	Rice yield (in tone) per hectare							
	Autumn rice	Change %	Winter rice	Change %	Summer rice	Change %	Total rice yield	Change %
1960	0.6940		1.001		1.102		0.933	
1965	0.7300	5.19	0.977	-2.40	1.119	1.54	0.942	1.03
1970	0.7190	-1.51	1.080	10.54	1.300	16.18	1.033	9.65
1975	0.8040	11.82	1.150	6.48	1.348	3.69	1.101	6.56
1980	0.8020	-0.25	1.171	1.83	1.460	8.31	1.144	3.93
1985	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
1990	0.9030	0.00	1.381	0.00	1.716	0.00	1.333	0.00
1995	0.9200	1.88	1.425	3.19	1.794	4.55	1.380	3.49
2000	1.0540	14.57	1.495	4.91	2.219	23.69	1.589	15.20
2005	1.0110	-4.08	1.436	-3.95	1.925	-13.25	1.457	-8.33

Source: Directorate of Agriculture, Government of Assam

Table 5. Trend of production of different types of rice in the Brahmaputra valleyduring 1960-2005

Year	Production (in tonne) of different types of rice							
	Autumn rice	Change %	Winter rice	Change %	Summer rice	Change %	Total rice	Change %
1960	207367		1073666		2137		1283170	
1965	309429	49.22	1099101	2.37	9803	358.73	1418333	10.53
1970	379573	22.67	1604317	45.97	32539	231.93	2016429	42.17
1975	477633	25.83	1767283	10.16	45506	39.85	2290422	13.59
1980	501692	5.04	1977606	11.90	43499	-4.41	2522797	10.15
1985	507500	1.16	2293700	15.98	45380	4.32	2846580	12.83
1990	522189	2.89	2565423	11.85	182581	302.34	3270193	14.88
1995	516031	-1.18	2622667	2.23	251324	37.65	3390022	3.66
2000	557764	8.09	2759652	5.22	681027	170.98	3998443	17.95
2005	335120	-39.92	2046719	-25.83	530302	-22.13	2912141	-27.17

Source: Directorate of Agriculture, Government of Assam

Change in cropping intensity

The nature of change in cropping intensity in the Brahmaputra valley has been also remarkable. In the traditional subsistence agriculture, usually the cropping intensity remains considerably high. In the limited land resources of the valley, the small and marginal farmers are compelled to cultivate their lands three to four times to raise various crops in order to meet their domestic demand. However, at present, because of the spread of modern mono-cropping, particularly in the case of rice, the paddy lands have been cultivated less intensively.

The cropping intensity in the case of Brahmaputra valley in 1992-93 was 150.31 % which decreased to 144.19 % in 2001-02. A district level observation of the change in cropping intensity over the period **(Table 6 and Fig. 4)** revealed that Darrang district recorded the highest decline (-37.99) in the index of cropping intensity followed by Barpeta (-11.03), Golaghat (-8.36), Nagaon (-6.73), Kokrajhar (-3.94) and Sibsagar (-3.74). However, the intensity of cropping has shown a positive trend in the remaining districts. The highest increase in the intensity was recorded in Dhemaji district (+23.21) and the lowest in the Dibrugarh district (+0.94).

Table 6. Changes in cropping intensity in the Brahmaputra valley, 1992-2002

District	Cropping intensity 1992-93	Cropping intensity 2001-02	Change (%)
Dhubri	151.33	153.29	+1.30
Kokrajhar	166.28	159.73	-3.94
Bongaigaon	156.12	164.79	+5.55
Goalpara	125.64	136.84	+8.91
Barpeta	172.93	153.85	-11.03
Nalbari	133.11	137.46	+3.27
Kamrup	125.28	139.73	+11.53
Darrang	231.4	143.49	-37.99
Sonitpur	136.81	147.12	+7.54
Lakhimpur	163.54	172.05	+5.20
Dhemaji	131.43	161.93	+23.21
Morigaon	131.25	134.55	+2.51
Nagaon	162.13	151.22	-6.73
Golaghat	140	128.3	-8.36
Jorhat	131.2	142.62	8.70
Sibsagar	115.49	111.17	-3.74
Dibrugarh	128	129.22	+0.94
Tinsukia	136.17	141.83	+4.16
Brahmaputra Valley	150.31	144.19	-4.07

Source: Directorate of Agriculture, Government of Assam; Note: Cropping intensity = (Gross cropped area ÷ Net cropped area) × 100

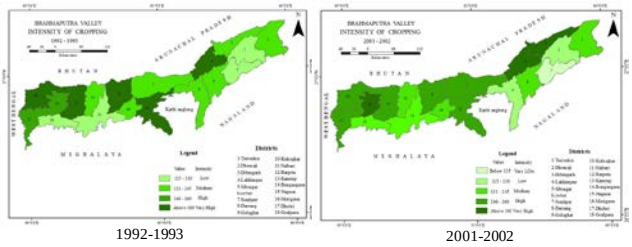

Fig. 4. Brahmaputra Valley Intensity of Cropping 1992-1993 and 2001-2002

Change in physiological density: There has also been seen a change in the physiological density of population in the Brahmaputra valley. It has already been mentioned that the Brahmaputra valley, with extensive uninhabited and uncultivated fertile lands attracted immigrants from East Pakistan (Bangladesh) and Nepal, especially after 1950s. The immigrants along with the growing indigenous population exerted immense pressure on the valley's limited agricultural lands.

It has been observed that the physiological density in the valley in 1991 was 798 persons per sq km which increased to 947 persons in 2001, registering a change of +19 % during the decade (Table 7).

Table 7. Change in physiological density in the Brahmaputra valley, 1991- 2001

District	Physiological density, 1991	Physiological density, 2001	Change (%) 1991-2001
Dhubri	888	1139	+28
Kokrajhar	931	1067	+15
Bongaigaon	824	953	+16
Goalpara	857	1037	+21
Barpeta	766	915	+19
Nalbari	687	748	+9
Kamrup	1124	1402	+25
Darrang	627	733	+17
Sonitpur	874	1014	+16
Lakhimpur	783	890	+14
Dhemaji	684	907	+33
Morigaon	666	840	+26
Nagaon	806	986	+22
Golaghat	662	806	+22
Jorhat	697	833	+20
Sibsagar	639	764	+20
Dibrugarh	834	859	+3
Tinsukia	1024	1156	+13
Brahmaputra Valley	798	947	+19

Data source: Statistical Hand Book, Government of Assam, Note: Physiological density denotes persons per sq km of arable land.

Causes of change: The changes in agroecosystem of the Brahmaputra valley are caused by a number of physical and cultural factors. Among the physical factors spatial distribution and seasonal variation of rainfall, humidity and temperature, floods and erosion, deterioration of soil quality and degradation of wetlands are mainly responsible. Since rice is cultivated extensively in the monsoon season, floods cause great loss to the paddy cultivation in the valley. The area and production of rice in major flood years (1988, 1998, 2004 etc.) were found to be less than normal (Fig. 5 and 6).

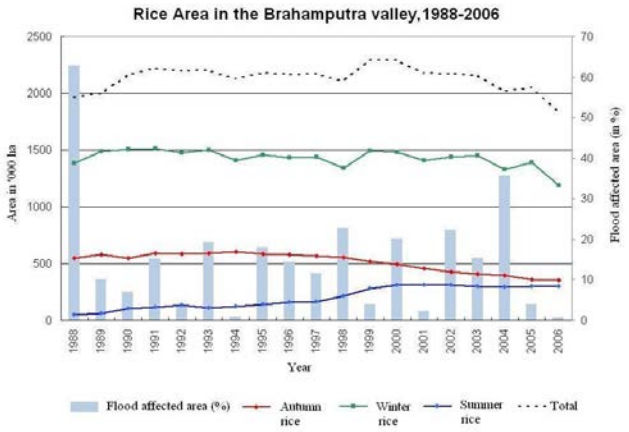

Fig. 5. Rice Area in the Brahmaputra valley 1988-2006

Again, the rapid population growth, occupational shift, modernization in agricultural and allied sectors, change in food and dress habit and housing, impact of globalization and government policies are some of the important socio-economic factors that contribute to the change in nature and functions of the agroecosystems in the valley. The rapid rise of population and limited supply of land resources in the Brahmaputra valley have adversely affected the valley's agroecosystem. It is already mentioned that the density of population in the valley has been rising fast from 225 in 1971 to 342 in 1991 and 406 persons per sq km in 2001. The agricultural density in the Brahmaputra valley which was 707 persons per sq km of agricultural land in 1991 increased to 824 persons in 2001 registering a change of + 17% during the period.

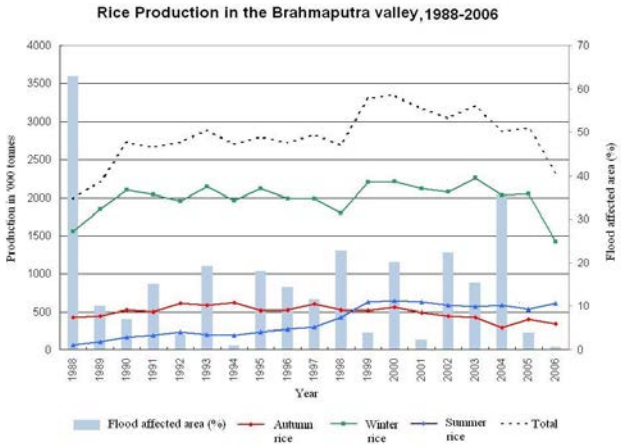

Fig. 6. Rice Production in the Brahmaputra valley 1988-2006

After independence, more particularly after 1980s, efforts have been made to use modern inputs and equipment in the agricultural fields which has brought about change in the land use pattern, methods of water supply, cropping pattern, crop-combination, productivity and the overall character of the agroecosystems of the Brahmaputra valley.

Consequences of change: The changes in agroecosystem for the purpose of modernization have generated lot of changes in the culture, economy and livelihoods of the people of the valley. With the introduction of modern inputs and implements the diverse and mixed cropping systems in the valley tended to be mono-cropping. Many traditional crop varieties that adapted to the site-specific conditions and practices now tend to disappear. With the disappearance of certain local crop varieties as well as indigenous agricultural tools, there has been a parallel disappearance of some agriculture-related customs and festivals, traditional house type, food and dress habits. These have slowly led to the withdrawal of the emotional attachment of the people with their agriculture. Earlier, people used to have a biasness for their own agricultural produces.

There has been a growing social negligence to the farming community and the traditional farming activities. As a result, the percentage of workers engaged in agricultural activities has significantly decreased. All these factors have, however, compelled at least some of the farmers to gradually opt for mechanized farming. Growing dependence on mechanization has ultimately displaced farmers and farm workers from the agriculture to other secondary and tertiary sectors of the economy. The cumulative effects of all these have rendered the agroecosystems gradually unsustainable causing poverty and marginality among the small farmers in the valley.

Moreover, the low return of agriculture, general negligence to the farming community, lack of irrigation facility, gradual change in food habit, adoption of HYV and related farming packages are held responsible for the declining trend of cropping intensity during the recent years. Again, there has also developed a psychological reluctance among the aged group of farmers towards the use of modern farm technology due to lack of training and orientation (Deka and Bhagabati, 2010). Further more, the rapidly growing population due primarily to immigration from the erstwhile East Pakistan during and after 1950s and the consequent rise in demand for food, fibre and fuel on the one hand and the rich-biased development programmes implemented by the government agencies and the changing socio-political situations on the other, have weakened the traditional organic agroecosystems that dominated the valley's agricultural scenario till recently.

The agroecosystems of the Brahmaputra valley, Assam have been evolved by the people of different ethnic groups sharing different ecological settings. During the early pre-Ahom period, the valley's agroecosystem was primitive in nature. The indigenous tribal people living in the highlands have developed agroecosystems following the shifting (*jhum*) system. The Ahom, who came to Assam during early 13th century are said to have introduced the wet rice cultivation and some other crops using tools like wooden plough, harrow etc. During the British colonization in Assam in the 19th and first half of 20th century, the land revenue system, land reclamation etc were introduced and thus provided a new configuration to the valley's agricultural systems. Again, after independence, due to high growth of population and resultant demand for food, and advancement of modern agricultural technologies, the highly diverse and traditionally evolved agroecosystems of the valley has been in the process of transformation. Thus, the agricultural ecosystems in the valley are no doubt in a state of transformation from traditional to a modern one. However, some elements of primitive and traditional society and culture are still found to characterize the basic tenets of the valley's agroecosystems.

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J. Agrofor. Environ. 11 (1 & 2): 67-70, 2017 ISSN 1995-6983

Rice-based cropping system of different ethnic groups across the Brahmaputra floodplain in Assam, India

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Abstract: In Assam, various ethnic groups have traditionally engaged in agriculture, especially rice cultivation in the Brahmaputra floodplain. It is important for agricultural development to understand how these people technologically adapt to the low-lying floodplain environment and how much variations are there among cropping technology of different ethnic groups. This study revealed the regional differences of rice-based cropping system among the different ethnic groups living in the Brahmaputra floodplain through a comprehansive field work in 32 villages. The results show that the present rice-based cropping system has little relation with ethnic background, but it is based on local ecological condition. Both traditional and modern technology shows some regional pattern within the Brahmaputra floodplain, which may be caused by interaction of both indigenous people and immigrant people.
Key words: Rice cultivation, cropping technology, ethnic groups, Brahmaputra floodplain, Assam

Introduction

In Assam of Northeast India, rice is traditionally grown in the low-lying floodplain formed by the mighty Brahmaputra coming down from the Himalayas. Till today, most of the population in Assam has been engaging in rice cultivation, and the considerable portion of the state economy (about 45% of Net State Domestic Products) depends on agricultural sector (Daimari, 2008). The rice cultivation in Assam, however, still using various kinds of traditional technologies and the productivity is much lower than the national average (1576 kg/ha in Assam and 2130kg/ha in All India in 2009/10 from Gov. of India 2011). Moreover, influence of natural hazards such as floods and droughts is not negligible. Modernization of agricultural sector including rice cultivation is the urgent task of the state government.

Many researchers studied problems of rice cultivation in Assam for agricultural development (e.g. Das, 1985; Bhagabati and Das, 1992; Singh, 2006). However, the methodological problem is that most of them are using district-level statistical data. These studies often focus on output of rice cultivation such as yield or economic value per area, and hardly consider the cropping technology which peasant farmers are using in their paddy fields. The information on existing cropping technology is fundamental for agricultural development, but it is not studied much in Assam. Moreover, northeast India including Assam is the home of different ethnic groups such as Aryans, Tibet-Burma, Tai group. It is also important to know how these people with different cultural background have historically developed the rice-based cropping system in the Brahmaputra floodplain.

This study reveals the rice-based cropping systems of different ethnic groups living in the Brahmaputra floodplain through extensive village survey, and discusses the regional differences and ongoing changes of the system.

Materials and Methods

Field work was carried out at 32 villages in 12 districts in the Brahmaputra floodplain in Assam during September to December 2011 (Fig. 1). The dominant group is Hindu Assamese (Aryans) in 12 study villages, Ahom (Tai group) in 5 villages, Bodo, Kachari, Mishing, Rabha, Mutok (Tibet-Burma group) in 2 villages each, Muslim Assamese, Ex-Tea garden tribe, Koch (Aryans), Karbi, Deori (Tibet-Burma group) in 1 village each. The average distance of study villages from nearest town is about 10 km (Max. 25 km, Min. 2 km). They are located in different ecological zones of piedmont plain, alluvial plain and floodplain.

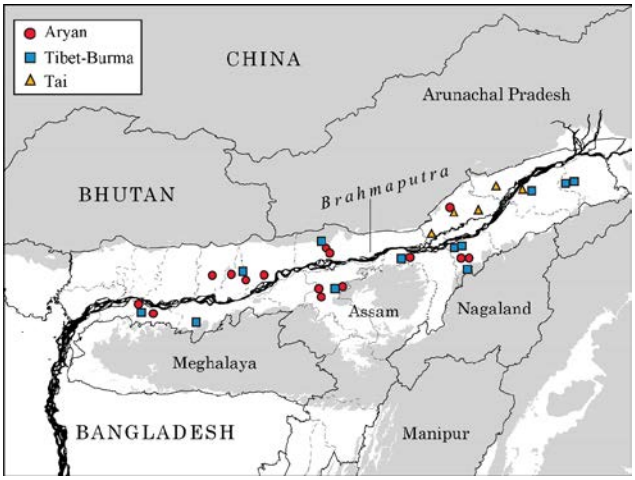

Fig. 1. The Brahmaputra floodplain and the study villages (Note: Altitude above 300 m is gray shaded.)

Primary data were collected in the study villages through questionnaire survey from male farmers in local language (Assamese language). The questionnaires include questions on village information (approximate household number, ethnicity, foundation year etc.), cropping pattern (both present and before), cultivation practices (transplanting, weeding, harvesting, threshing etc.), rice variety (local variety, modern variety etc.), agricultural implements (both traditional and modern), paddy field condition (location, soil quality etc.).

Results

It is well known that there are three kinds of traditional rice group in Assam grown in different season and ecological condition; *Ahu*, *Bao*, *Sali*. *Ahu* is the broadcast rice grown from February to June in higher paddy fields. *Bao* is also broadcast rice but grown from February to November in lower fields. *Sali* is the transplant rice grown from June to November. These rice correspond to *Aus*, broadcast *Aman* and transplant *Aman* in Bangladesh. In all study villages, regardless of ethnicity, any of these rice are grown (Fig. 2a). Among three rice, transplant rice *Sali* is

cultivated in all villages, but *Ahu* and *Bao* are cultivated only in some villages.

Fig. 2. Cropping pattern of the study villages (a) present, (b) before. (Source: Author's fieldwork)

The variation of cropping pattern is attributed to rather ecological and economic condition than ethnic background. When compared to former cropping pattern, nowadays *Ahu* and *Bao* rice was abandoned in some villages (Fig. 2b). Farmers insist rainfall decrease and low yield are the main reasons of this change. They could not continue broadcast rice due to rainfall decrease, and some farmers started to cultivate the same variety as transplant rice. After stopping rice cultivation, some farmers started wage labour and others converted their paddy fields in higher land into private tea garden to earn stable and more profit. Only in the western and central part of the state, *Boro* rice, which is grown from December to May in dry season, was introduced with irrigation facilities.

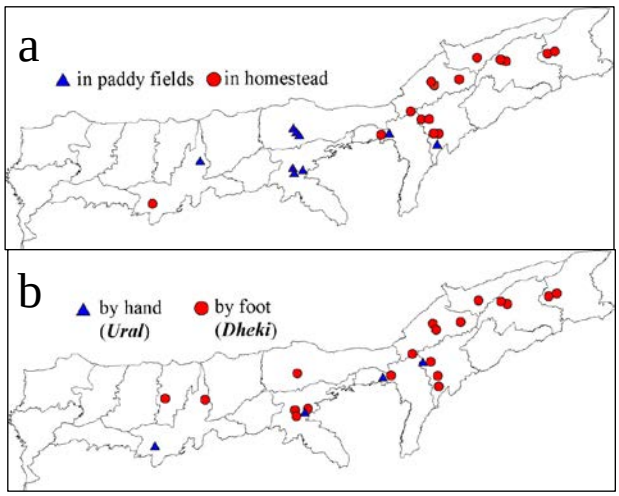

Fig. 3. Cultivation practices in the study villages (a) seedbed, (b) milling. (Source: Author's fieldwork)

There is not much difference in cultivation practices among study villages. It was found that broadcasting season of *Ahu* and *Bao* rice or transplanting season and harvesting season of *Sali* rice is almost same in all villages. However, minor differences can be seen in seedbed preparing, weeding, threshing and milling. In the villages of eastern (western) Assam, they prepare seedbed in their homestead (paddy fields) (Fig. 3a). In threshing, some ethnic groups like *Mishing* use their foot for threshing rice while others use cows or tractors (no figure). In milling rice, people of *Mishing*, *Karbi* and *Rabha* use wooden mortar by hand (*Ural)*, while others use wooden mortar by foot (*Dheki*) (Fig. 3b and Fig. 4).

Fig. 4. Traditional wooden mortars. (a) *Ural*, (b) *Dheki*. (Source: Author's fieldwork)

There can be seen the specific regional difference of plough (*Nangal*) type (Fig. 5). In the Brahmaputra floodplain, traditional plough is still used for land preparation along with harrow (*Moi*), both implements are pulled by two bullocks. Different kinds of plough are used together for different purpose. In many villages, wooden plough (*Kathor Nangal*) and iron plough (*Rohar Nangal*) are used (type I in Fig. 5 and Fig. 6). In the western part, iron plough is not used but two kinds of wooden plough (*Soja Nangal*, *Buta Nangal*) are used (type II). In the eastern part, they also use two kinds of wooden plough, one of which bottom has a longer shape (*Fanforiya Nangal*) (type III). In two villages of the eastern most district, they only use *Fanforiya Nangal* (type IV). This difference of plough type does not seem to be related with ethnicity.

Fig. 5. Different type of ploughs. (a) *Kathor Nangal* (bottom) and *Rohal Nangal* (top), (b) *Soja Nangal* (right) and *Boja Nangal* (left), (c) *Fanforiya Nangal* (right) and *Kathor Nangal* (left), and (d) *Fanforiya Nangal*. (Photos of I, III, IV are taken by author, Photo II by Nityananda Deka)

There are so many local rice varieties in Assam, but nowadays many farmers grow High Yielding Varieties (HYVs) as it has higher productivity than local variety. HYV is grown in all study villages, but its popularity is higher in the western Assam (Fig. 7a). In the eastern Assam, local variety is still popular mainly for its taste. Among local varieties, glutinous rice or sticky rice locally called *Bora Chaul* is the special variety for local people as the rice cake (*Pitha*) or daily light meal (*Jolpan*) is made from this variety. This variety was found in almost all study villages, but the local name is different in some villages especially in the western Assam (Fig. 7b).

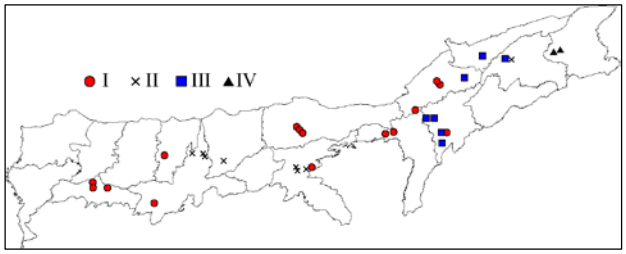

Fig. 6. Plough type of the study villages. I, II, III, IV are given in text. (Source: Author's fieldwork)

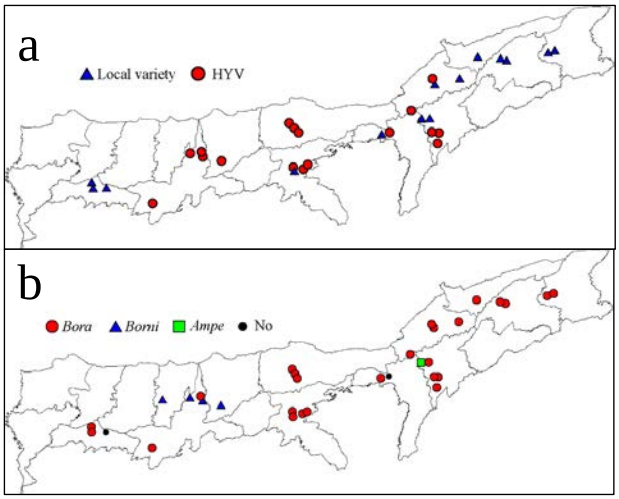

Fig. 7. Rice variety of the study villages (a) most popular variety, (b) name of the glutinous variety. (Source: Author's fieldwork)

Finally, introduction of modern inputs for rice cultivation was investigated. Cultivating machinery such as power tiller or tractor is introduced into almost all villages. These machineries are used for land preparation along with bullocks. Chemical fertilizer is also used in many villages along with traditional cow dung but it is not used in some villages in eastern Assam (Fig. 8a). Irrigation facilities such as power pump and tube well are used in the villages in the western and central Assam, but not in the eastern Assam (Fig. 8b). These modern inputs were brought to study villages after the 1990s. Introduction of these modern inputs are gradually carried on in all ethnic community.

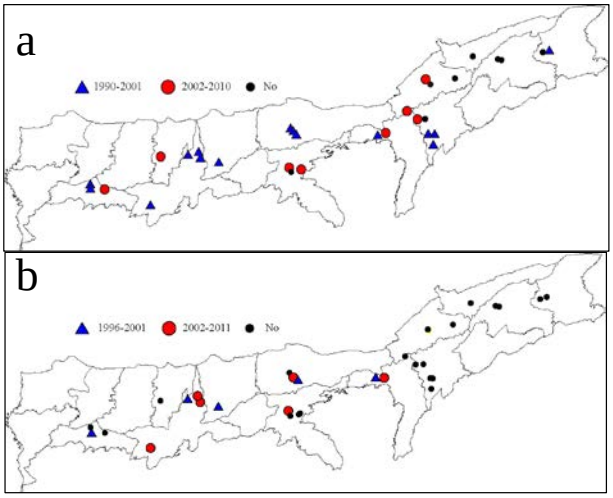

Fig. 8. Introduction of modern inputs in the study villages (a) chemical fertilizer, (b) irrigation facility. (Source: Author's fieldwork)

Discussion

From the above results, it can be said that rice cropping technology in the Brahmaputra floodplain is rather uniform among the different ethnic community, though a few of cultivation practices are different by ethnic community. However, It should be noted that there are some regional patterns among the distribution of traditional technology. Especially, the plough type is clearly different between eastern and western part of the state. As for modern technologies, most of these technologies were introduced during the 1990s and 2000s, but they can be found more in the villages of the western Assam. Why these regional patterns are seen among the cropping technologies?

Local farmers explained that interaction with farmers from other villages had enabled transfer of new technologies. One farmer from Ex-Tea garden tribe community said they spoke their own language and kept unique culture in the village. They had little experience to interact with people from other community before, but nowadays they accept general Assamese culture such as food habitat and festivals to a large extent. They have many opportunities to learn cropping technology from other village, and this is one explanation why differences of traditional technology become small over the ages in the neighboring region. The assimilation between different communities was also reported in the previous study (Nath, 2003), but its effect on technology diffusion should be studied more.

There are also answers of why modern technologies are introduced more in the western part of the state. One farmer from Assamese community in Nagaon District (central part of Assam) said Muslim immigrants came to sharecrop in his village because the immigrants owned only a small size of paddy fields. They started to grow *Boro* rice in the tenanted land, and the indigenous villagers could learn the *Boro* rice cultivation from them. Another farmer from Assamese community in Goalpara District (western part of Assam) also had interaction with Muslim immigrants in his village. The immigrants started to use chemical fertilizer which accelerated the growth of rice. After harvesting rice in the earlier season, they kept cows

in the paddy fields. Then the indigenous Assamese farmers too had to use chemical fertilizers, otherwise stray cows could come to eat the un-harvested rice in their paddy fields. In these ways, modern technologies have been gradually introduced in the central and western part of the state where many Muslim immigrants live among indigenous Assamese community.

Apart from the villagers' interaction with different community, agricultural office in the nearest town also plays the important role for extending modern inputs. Introduction of modern inputs largely depends on the availability of schemes from agricultural office. One Assamese farmer said they started *Boro* rice cultivation because the government provided them with rice seed as a demonstration. On the other hand, another Assamese farmer complained that the government does not provide any irrigation equipments, which could enable *Ahu* rice cultivation in his uncultivated land. However, only the distance form nearest town cannot explain the availability of government scheme in each study village, and more research will be required on how the villagers bring new technology from the office.

Conclusion

The present rice-based cropping system in the Brahmaputra floodplain shows little differences among the ethnic communities, but some regional characteristics are seen in the use of both traditional and modern technologies. Interaction with indigenous people and immigrant people from different ethnic community may be related with the technology diffusion. Therefore, historical interaction of different ethnic community should be studied for understanding the present rice-based cropping system and future agricultural development in the state.

Acknowledgments: I am grateful to Prof. A. K. Bhagabati, Department of Geography, Gauhati University, and Mr. Nityananda Deka, Department of Geography, Nagaon Girls College for their help during my field work. I also extend my gratitude to professors in regional colleges of Assam and villagers who helped my survey in the villages. This study was supported by Grant-in-Aid for JSPS Fellows (11J00348).

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J. Agrofor. Environ. 11 (1 & 2): 71-75, 2017 ISSN 1995-6983

Practical education for environmental awareness: education children on the arsenic contamination issue in Bangladesh

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Abstract: This paper aimed to report the findings of an experimental education project designed to address the arsenic awarness issue in Bangladesh. The project successfully build up a useable education model: while it generated some immediate and actual benefits. As such the model/process that has been developed through this project may be reciprocated elsewhere for its sustainable use and long-term benefits.
Key words: Education, environmental awareness, arsenic contamination.

Introduction

The arsenic contamination of groundwater is one of the main environmental issues in Bangladesh, and about 38 million people are currently at risk (Tani, 2005). It stems from excessive irrigation practices that are intended to prevent the spread of dysentery and cholera through stagnant pond water, and to enable poverty reducing crop cultivation in the dry season. It could be said that, ironically, efforts to secure supplies of safe water have caused even more serious water pollution issues. One of the most effective measures for keeping water safe is to provide villages with deep tube wells, however there are insufficient funds to endow all villages with this resource. Since arsenic contaminated water can still be used for some agricultural purposes or other livelihood activities, distinguishing between water that is safe for drinking and water that is only appropriate for other usages has been a priority. Furthermore, some research by the Bangladeshi Government has revealed that people who receive sufficient nutrition are less affected by arsenic poisoning.

Bangladeshi governmental and non-governmental organizations have conducted water tests to identify the areas and individual tube wells known to be contaminated by arsenic, and have painted the affected wells in red and the arsenic-free wells in green (MoLG, 2004). Fig. 1 shows the areas where ground water has been contaminated with arsenic. Research has shown that the southern low-lying areas have been particularly affected.

This paper is going to report on an experimental environmental education project designed to address the arsenic issue in Bangladesh. The project aimed to build a practical educational model that would provide children with knowledge of the issue, whilst simultaneously promoting the need for "a healthy body to avoid the arsenic affect" by motivating them to adopt proper eating habits. The project has two main purposes: (i) To give children the knowledge they need to avoid, or build their resistance to crucial environmental issues in their living environment, (ii) To build a comprehensive model of enlightenment education for school teachers and children through a participatory workshop method.

Implementation System of the Project

Four primary schools, located in the Barisal district, an area seriously affected by arsenic contamination, were chosen for the experiment. These were built and managed by a Bangladeshi NGO named Basic Development Partners (BDP), and have received economic support from Japanese NGOs. BDP has provided non-formal primary education in Bangladesh since 1990, particularly in remote areas. Now they have 74 schools in six administrative areas, and 29 of them are in the Barisal district. BDP selected the four target schools for this project from amongst this group.

The project team, named "Water Smile Project (WSP)", comprised a researcher (myself), BDP staff, several school teachers, and a few Japanese volunteers from JAFS (Japan Asia Friendship Society), which is one of BDP's donor agencies in Japan. The project receive the financial support from Ajinomoto Ltd.

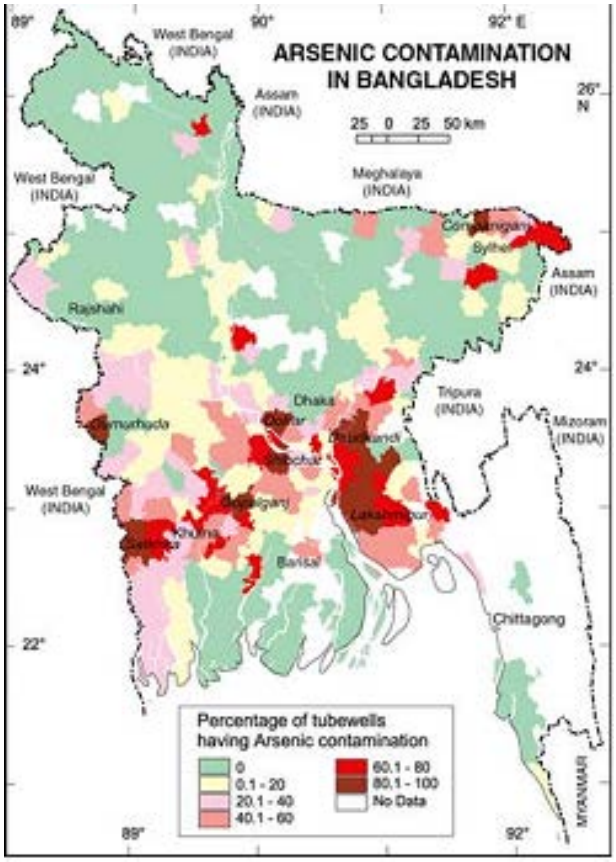

Fig. 1. Map of Arsenic Contamination Area Source: Banglapedia

The project had three main stages, with the latter two experimental practices based on research gathered during the first stage;

i) Participatory research and establishing the children's life environment.
ii) Making teaching resources to provide children with the appropriate knowledge and motivation to discuss their water utilization.

iii) Promoting proper nutritional habits for improved health through the provision of vegetable seeds.

Fig. 2. Research and Mapping Chart

Plate 1. Completing the chart

Participatory research and establishing the children's life environment:

For the first stage, the project team conducted research on the children's life environment, with the help of the children, and established the level of their knowledge of arsenic. This research was intended to give the researchers an understanding of the children's living conditions, and also to make children more aware of their own environment. We divided ourselves into several groups, each group consisting of 10 children from classes 4 and 5, their teacher, a BDP member of staff, and two Japanese members. They visited children's homes and completed the research mapping chart (Fig. 2 and Plate 1). In total, 48 sample swere collected from our research at the four target schools.

The chart has six main parts:

i) Basic information about the family (family members, income, micro-credit[1] use)
ii) Children's everyday routines
iii) Food (contents of meals based on the previous day's lunch and dinner, and the current day's breakfast)
iv) Home garden and livestock
v) Water utilization, and the number of steps from the house to the pond and the tubewell used by the family
vi) Knowledge about arsenic and common associated illnesses.

Plate 2. Taking photos of their own living environment

On the back of the chart, the children drew the layout of their house. They also took photos of whatever caught their attention, such as their house, their home garden, or their livestock (Plate 2). These activities encouraged the children to take note of their living environment, and things they usually paid no special attention to.

The research clarified four key points:

First, most of the children's families use a Micro-Credit program (MC), and have loans significantly in excess of their income. Of the 48 families, 46 use MC and owe approximately five times their income (the average income is 3,095 Taka, whilst the average debt is 17,015 Taka). Some families have accumulated debt from more than one NGO.

Table1. Fruit and Vegetables from Home Gardens

gourd	balsam pear	pumpkin	*chichinga*	radish	*kakkuro*	potato	*kochu*
10	2	6	4	1	2	1	2
okra	root clump	egg plan	basil	*data*	*lalshak*	*shapra*	chili
3	1	6	13	2	7	1	5
guava	grapefruit	mango	jackfruit	litchi	papaya	coconut	banana
21	6	22	14	8	24	27	7
tal	pomegranate	*bel*	lemon	*gup*	*pam*	*amra*	palm
1	1	2	3	1	1	3	6
wheat	betel palm	blackberry	jute	nut	vegetable	fruit	none
1	1	6	3	4	(1)	(1)	(8)

Table 2. Contents of Meals

Foodstuff	wheat	rice	potato	dhal	meat	fish	egg	milk	vegetable
Breakfast	9	29	20	5	1	3		1	1
Lunch		29	6	14	2	20			2
Dinner	2	23	3	11	1	14	1	1	2
	pumpkin	*shapra*	papaya	coconut	spice	basil	*zira*	onion	turmeric
Breakfast			1		13			7	12
Lunch	1	2			17	4	2	12	17
Dinner	1	2		1	12	1	1	12	10
	chili	garlic	salt	oil	cinnamon		tea	sugar	
Breakfast	13	5	17	11	1		4	3	
Lunch	15	4	23	18	2				
Dinner	14	5	14	10	2			1	

Table 3. Water Utilization

Water	Tube well	Pond	Small Pond	Big Pond	River
Drink	44	3	0	1	0
Cook	5	39	0	0	4
Wash Dishes	3	40	2	0	2
Wash Clothes	3	40	1	0	3
Toilet	5	38	2	0	2
Livestock	6	34	2	1	4
Bath	7	36	1	0	3

Table 4. Common Disease and the Treatment

Common Disease	cold	fever	cough	headache	stomachache	earache	toothache
	22	43	25	8	10	1	2
	loose bowels		tear	numbness	hand-foot pain		breathe difficulty
	5		1	1	1		1
Solution	Doctor		Medicine	Natural Medicine	Shaman		ORS
	44		2	1	1		1

Second, although people cultivate several kinds of fruit or vegetables in their home gardens (Table 1), the children seldom eat them (Table 2). One reason is that they are often grown as cash crops funded by MC loans, with the result that the families often sell them to buy essential goods such as rice, salt or oil, or to repay their loan, rather than eat them.

The third point is about water utilization. The families have already stopped using the shallow tube wells which have been contaminated with arsenic. Instead, they get general-purpose water from the ponds (Table 3) that are located nearby most houses, and undertake longer trips to deep tube wells for drinking water. Since the number of deep tube wells is limited, and it is inconvenient or hard for most villagers to source water from there[ii], they reserve deep tube well water for drinking only. Of the 48 children in the research, 30 confirmed that their main chore at home was fetching water from the tube wells.

The last point is that the children's knowledge of arsenic exceeded our expectations. As the third point illustrated, they were already distinguishing between water suitable for consumption and for general usage, and people seldom suffered from arsenic-related illnesses. Ailments which were more common are listed in Table 4; these included colds, fevers or coughs which caused by a weak constitution, rather than infectious illnesses, such as diarrhoea, from contaminated water.

The findings indicate that the arsenic contamination is not only an environmental issue, but also related to their economic and social situation. The results were shared with BDP staff and the schools' teachers, to help determine what types of teaching materials were needed to make the children more aware of their living environment, and to motivate them to consume a more balanced diet.

Teaching materials to inform children about their environment

As mentioned above, the families have faced a sequence of issues; the spread of shallow tube wells prevented the contraction of infectious diseases from pond water, but introduced the new danger of arsenic contamination. Consequently they had to shift their supply of water once more, from the shallow tube wells to the deep tube wells. Similarly, whilst the Micro-Credit program has improved their economic situation in some ways, it has also turned their home-grown vegetables into cash crops intended for sale rather than for their children's mouths. These issues have not arisen through the any particular individual seeking to gain an advantage, but rather occurred in the pursuit of programs intended to benefit the public as a whole. Therefore, rather than seeking to proportion blame or find a single cause, it is more important to focus on improving the capacity of the public to adapt to new problems in their living environment. The project therefore focused on encouraging children to consider what they could achieve by themselves, rather than having to depend on information they are given.

One BDP staff member, who was from a village in Barisal, recounted his experience from his childhood, which provided the central idea for our project;

When I was a boy (he is now 52 years old), there were two ponds in my village. We used one pond to get drinking water, and the other for everyday tasks, like washing clothes, bathing, or for our livestock. Both ponds were shared within our community, and everyone kept the pond for drinking water clean and did not use it for anything else. However, if one of the villagers got an infectious illness, everyone avoided using the pond and children were sent to stay with relatives. They knew that there was a risk of being infected if they used the pond, and many of the illnesses in those days were fatal.

In order to tackle dysentery and *E. coli*, and to support the green revolution, irrigation facilities and tube wells spread through out the villages, and people no longer drank water from ponds. The shallow wells became the common source for water among the villagers, and in addition to reducing the risk of contracting infectious water-borne diseases, made it possible for people to cultivate rice during the dry season.

However, the arsenic problem then arose. People couldn't go back to using the ponds anymore, because they thought; "the pond water smells too bad to drink." They had stopped using different ponds for different purposes. Consequently they began shifting to deep tube wells, but this costs more than they can afford by themselves.

A proposal was developed to create a picture-based story that would represent the history of water in the region, and become a teaching resource that would provoke thoughtful discussion amongst the children. A workshop approach was chosen to produce the material, involving all 20 teachers from the four target schools.

At first, the project members discussed the plan, drafted a story and sketched pictures based on the history of water in the area. Then the teachers decorated the story and created detailed illustrations for each scene. Two teachers worked on each scene, and nine pictures were then selected to form the basis of the whole story, entitled "Story of the Ghosts Living in Water." Since children in the villages like and are familiar with ghost stories, we decided to person if the arsenic and associated diseasesas ghosts. The material was intended to provoke children into thinking about how they could deal with "the ghosts."

After revising the story and the pictures produced by the BDP teachers in the workshop, we tested the final product to evaluate how effectively it would convey the story tochildren. The teachers tried telling the story to some students to check if they could understand it or not. The story does not have a conclusion, but is open-ended in order to generate discussion in the classroom about what children could do about this issue by themselves. Some options are suggested, such as; thinking twice before reusing pond water, gathering and filtering rain water, keeping their environment clean, or eating a more nutritious diet to maintain their strength.

This particular story making process is significant for two reasons. First, the story was based on their own history, not dependent on knowledge of external or distant events, so that the children find it easy to understand that the problem is relevant to them. The other point is that the participatory workshop gave the teachers a sense of ownership over the resources, making it easier for them to use it in their classroom.

Vegetable "Seed Project" for improvement of children's nutrition

Our research and map of their living environment revealed the need to provide children with a guide to maintaining a properly balanced diet. This could also be considered one of the measures they could take to protect themselves from arsenic poisoning, as a well-nourished body has a better chance of resisting the effects of arsenic. Our storybook therefore included suggestions for building a stronger, heal thier body: "Vegetables and fruit have ingredients that keep your body in good condition. If you eat vegetables and fruit, you will be healthy and well, and your body will be strong enough to protect you from the bogey."

The project team, including the school teachers and the BDP staff, discussed ways to address this issue, which led to the "seed project". The project provided children with vegetable seeds and urged them to grow it at home and to eat the vegetables by themselves. The WFP (UN World Food Program) provided the children with biscuits at school, but temporarily providing food has a limited effect on the children's ability to improve their own nutrition. Creating sustainable habits that they could practice by themselves are needed. We supplied five kinds of vegetable seeds for the school children to plant in their garden at home for their own consumption. Since they would be able to get more seeds from their own crops, or could buy more quite inexpensively, the children could continue this practice without the need for continued project support.

Fig. 3. Worksheet of 'Seed Project'

Plate 3. Vegetable grown by children
Note: The low area of Barisal is often damage by floods, but they utilize the water flow to develop their cultivation system in the water

Usually children just help out in their family garden, seldom taking on the responsibility of growing anything themselves. But if they plant the seeds which they get from school and cultivate the vegetables by themselves, then in their cultural context, their parents would never sell those vegetable without the children's consent. The children could therefore eat those crops. At the same time, in addition to supplying the seeds, the teachers could also motivate the students to attend to the cultivation of the crops, for example, by setting assignments to report on how much they have grown, or by creating a competition to see who can raise the biggest pumpkin. The project assigned students an observation sheet to complete on vegetable growth (Fig. 3). One BDP member of staff said that, as Bangladesh is an agricultural economy, it is important for children to be familiar with cultivation.

Children at first planted the seeds in small pots, and then replanted them intheir garden at home (Plate 3). Their parents taught them how to do the planting.The BDP staff and the teachers pointed out the significance of this, explaining that the roles had essentially been reversed; instead of the children helping their parents at home, the parents were now helping their children. Although most parents had little experience of going to school by themselves, and could not help their children on many school matters, they were quite used to agriculture. This would be first time that parents had been able to help their children with their "homework". The significance of the seed project therefore includes the transformational effect it has had on family roles, and the way in which it has brought school and home closer together.

Fig. 4. Harvest Party at School

At the end of the project period, the children brought their crops to school and cooked and ate them together (Plate 4). The benefits of the project will be achieved if the children become accustomed to both cultivating and consuming the vegetables, something that must be viewed in a long-term context.

Conclusion: Repercussions as an educational model

While this project aimed to build a useable educational model, it generated some immediate and actual benefits. We focused on only four target schools, however other schools nearby soon expressed disappointment at not being included in the experiment. It means that the project generated some interest and consequently some benefits for them, just through the process of our experimentation. Outcomes such the story book and the seeds bank can be shared with other schools of course, but the process of this project should also be shared and reproduced; ensuring that the beneficiaries, in this case the teachers and children, also participated in the process and contributed to the project is a very important part of the model. If our workshop method, or the way in which the story book was created, could be adapted to other educational practices and other issues, then this experiment would be established as amodel for other projects. Therefore, we progressed carefully through the project stage by stage, and recorded the process in "The WSP News Letter", published six times in total, once for each stage of the project.

Our next challenge is to take into other schools this educational practice and the materials that were created, in order to address this issue else where and to improve their situation. Also, the model/process that has been developed through this project should be applied to other objectives.

Acknowledgements: This project was carried out from April 2010 to March 2012 with the generous support of Ajinomoto International Cooperation's "Nutrition and Health" Support Program. The publication of the teaching materials in Bangladesh was supported by the "Life and Green Project" at the Institute of Southeast Asian Studies of Kyoto University. I would like to take this opportunity to express my sincere gratitude for their support.

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J. Agrofor. Environ. 11 (1 & 2): 77-81, 2017 ISSN 1995-6983

Identification of traits related to drought tolerance in chickpea (*Cicer arietinum* L.) genotypes

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Abstract: Drought is the most common abiotic stress limiting chickpea production because chickpea is usually grown under the residual soil moisture. The experiment was carried out with 39 chickpea genotypes at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) during post-monsoon season of 2009-2010 based on alpha design with two replications under two set (rainfed and irrigated conditions) to observe information on yield under drought condition and potential yields and to investigate the relationship of physiological traits related to drought tolerance. Rainfed condition significantly reduced seed yield due to poor partitioning operated along with terminal drought stress. Nine genotypes resulted superior or similar to the seed yield of drought tolerant check genotype (ICC 4958) under rainfed condition. These genotypes were observed well performed under irrigated condition. The SPAD chlorophyll meter reading (SCMR) was increased but specific leaf area (SLA), and relative water content (RWC) were decreased under rainfed condition as compared to irrigated condition. This study also identified promising genotypes for high SCMR on ICCV 03110, ICCV 00108 and ICCV 04110, low SLA on ICCV 04303, ICCV 03302, ICCV 04301 and ICCV 01303 and high RWC on ICCV 00108, Yezin 6 and Yezin5. Results showed that the SCMR was significantly related with seed yield and SLA. The genotypes having high SCMR and low SLA seemed to be resistance to drought.
Key words: Chickpea, drought stress, drought tolerance traits, relationship, yield.

Introduction

Chickpea (*Cicer arietinum* L.) is an important food legume crop because of its high quality protein for the human diet and its straw for valued animal feed. It is grown in over 50 countries in all continents of the world. The major chickpea growing countries fall in the arid and semi-arid regions where terminal drought is one of the major constraints which affect the yield (Turner *et al*., 2001). This problem is more serious in Myanmar where chickpea is traditionally planted towards the end of the rainy season and generally grown on progressively declining residual soil-moisture. In some production areas, the rainfall is poorly distributed over the growing season and stops before growth of chickpea is completed even in case of early sowing. Consequently, terminal drought stress, which during the reproductive phase of the crop, is common and critical.

Yield losses due to terminal drought estimates range from 35 to 50% across the Semi-Arid Tropic (SAT) and West Asia and North Africa (WANA) (Sabaghpour *et al*., 2003). A large portion of the losses can be prevented through crop improvement and better drought adapted genotypes would reduce the yield losses. Several physiological, morphological and phenological traits have been listed to play a significant role in crop adaptation to drought stress (Ludlow and Muchow, 1990).Thus, alternative breeding strategies using physiological traits as selection criteria have been proposed by some researchers. Rapid progress in drought resistance breeding has been achieved in groundnut based on characters such as harvest index (HI), water use efficiency (WUE), specific leaf area (SLA), and SPAD chlorophyll meter reading (SCMR) (Nagam *et al*., 2005). Early studies have indicated differential responses for relative water content (RWC) in chickpea (Bahavar *et al*., 2009) and it was positively correlated with chlorophyll content and grain yield in rice under drought conditions (Pirdashti *et al*., 2009).

In addition, information on the heritability of these traits will be useful for planning the suitable breeding strategies for improving drought tolerance. Phenotypic correlations among these traits are also important when simultaneous selection of multiple traits is to be carried out for high yield under drought stress conditions. Therefore, the objective of this study was to observe information on yield under drought conditions and potentials yields and to investigate the relationship of physiological traits related to drought tolerance.

Materials and Methods

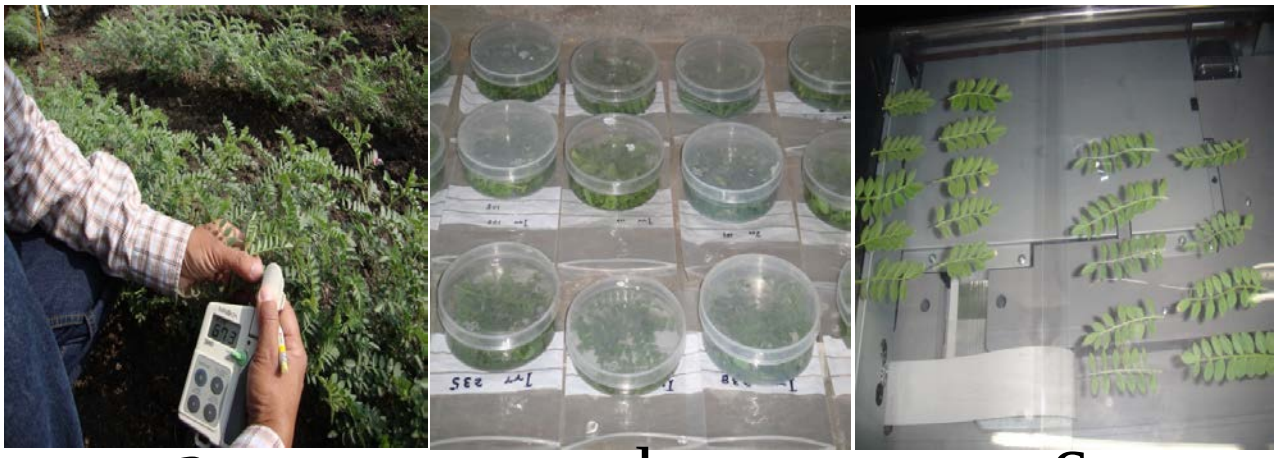
Experimental site, design and plant materials: The experiment was carried out at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru (17°30´ N; 78° 16´ E; altitude 549 m) in post-monsoon chickpea growing season (October-February) of 2009-2010. This study was evaluated in two sets (rainfed and irrigated conditions) of 13 x 3 alpha designs (39 genotypes) with two replications. Thirty-nine genotypes of chickpea which comprising 8 genotypes developed at Myanmar were evaluated. The plot size was 4 m length with a single row. Under irrigated treatment, furrow irrigation was applied at 40 days after sowing (DAS). Crop management for both trials was followed by ICRISAT's practices.

Data collection: Yield and yield attributes were recorded. Moreover, drought tolerance traits such as SPAD Chlorophyll Meter Reading (SCMR), Relative Water Content (RWC) and Specific Leaf Area (SLA) were measured at 75 DAS under both conditions (Fig. 1).

Statistical analysis: The data from each individual experiment were analyzed using the following linear additive mixed effects model: $Y_{ijk} = \mu + r_i + b_{ij} + g_k + e_{ijk,}$ where, Y_{ijk} = the observation recorded on genotype k in incomplete block j of replicate i, μ = the general mean, r_i =the effect of replicate i, b_{ij} =the effect of block j within replicate i, g_k =the effect of genotype k, e_{ijk} = the effect of the plot.

Using the above model, the statistical procedure of residual maximum likelihood (ReML) method with GenStat (version 12.1) statistical computing software was employed to obtain the unbiased estimates of the variance components δ^2_b, δ^2_g and δ^2_e, and the best liner unbiased predictions (BLUPs) of the performance of the genotypes. Heritability was estimated as $h^2 = \delta^2_g / (\delta^2_g + \delta^2_e)$. The significance of genetic variability among genotypes was

assessed from the standard error of the estimate of genetic variance δ^2_g, assuming the ratio δ^2_g/S.E. (δ^2_g) to follow normal distribution asymptotically. Moreover, the correlations were calculated separately in both conditions for seed yield and drought tolerance traits.



Fi.g. 1. (a) SPAD Chlorophyll Meter Reading, (b) Relative Water Content determining, and (c) pecific Leaf Area (scanning)

Results

Seed yield: The analysis showed significant genotypic differences for seed yield under rainfed and irrigated conditions (Table 1). The mean, range and heritability of seed yield were low under rainfed condition comparison with irrigated condition. Under rainfed conditions, the highest seed yield was found in PCHL 04-5 (2985 kg ha^{-1}) followed by ICCV 03107 (2905 kg ha^{-1}), Annigeri (2854 kg ha^{-1}), ICCV 00108 (2715 kg ha^{-1}) and the drought tolerant genotype ICC 4958 (2675 kg ha^{-1}), while the lowest in ICCV 03406 (1351 kg ha^{-1}) (Table 2). This was due to significantly higher in their yield attributes *viz.*, biomass yield, HI and number of pods per plant of these genotypes (data not shown). Under irrigated condition, the highest seed yield was observed in ZCHL 05-2 (3701 kg ha^{-1}) followed by Shwenilonegi (3605 kg ha^{-1}), while the lowest yield was in Yezin 5 (1578 kg ha^{-1}) (Table 2).

Table 1. Trial mean, range of best linear unbiased predicted means (BLUPs) and variance of seed yield and drought tolerance traits of chickpea genotypes under rainfed and irrigated conditions at ICRISAT during post-monsoon season, 2009-2010

Traits	Trial mean	Range of predicted means	δ^2g	S.E	Significance	Heritability (h^2)
Seed yield (kg ha^{-1})						
Rainfed	2236	1351-2985	88991	38792	*	0.37
Irrigated	2725	1578-3701	101854	48153	*	0.42
SCMR						
Rainfed	64.98	57.99-70.07	4.40	1.47	**	0.56
Irrigated	60.32	56.02-66.78	4.03	1.46	**	0.52
SLA						
Rainfed	208.8	150.8-291.5	913.3	290.2	**	0.59
Irrigated	232.2	185.3-306.3	650.2	225.9	**	0.53
RWC						
Rainfed	78.97	69.66-86.03	13.35	6.54	*	0.35
Irrigated	81.44	70.90-95.85	9.18	3.78	*	0.44

*, **, Significant at the p≤0.05 and p≤0.01, respectively

Physiological traits related to drought tolerance:

***SPAD Chlorophyll Meter Reading (SCMR)*:** Significant differences were also observed among the tested genotypes for SCMR under both rainfed and irrigated conditions (Table 1). The mean, range and heritability of SCMR were high under rainfed condition comparison with irrigated condition. Under rainfed condition, ICCV 03110 showed the highest SCMR of (70.07) followed by ICCV 00108 (69.05) and ICC 4958 (68.15). Under irrigated conditions, these genotypes also showed high in SCMR readings (Table 3).

Specific Leaf Area (SLA): There was a significant reduction in SLA under rainfed compared to irrigated conditions. In this study, genotypic differences for SLA were found to be significant under rainfed and irrigated conditions (Table 1). This finding was supported by good heritability of SLA. Low SLA is preferable as it indicates higher drought tolerance. The lowest SLA was obtained in

ICCV 04303 (150.8 cm^2g^{-1}) followed by ICCV 03302 (157.0 cm^2g^{-1}) and ICCV 04301 (158.1 cm^2g^{-1}) (Table 3). The values of these genotypes were significantly lower than that of ICC 4958. Under irrigated conditions, there were no genotypes significantly better than ICC 4958. However, nine genotypes showed consistency results of lower SLA under both rainfed and irrigated conditions.

Table 2. Seed yield (kg ha^{-1}) of chickpea genotypes under rainfed and irrigated conditions at ICRISAT during post-monsoon season, 2009-2010

Genotypes	Rainfed yield	Irrigated yield
Annigeri	2854	3464
ICCC 37	2082	3118
ICCV 00108	2715	2968
ICCV 00401	2031	2939
ICCV 01303	2500	2225
ICCV 03103	1735	3444
ICCV 03107	2905	2457
ICCV 03110	2609	2759
ICCV 03111	2368	2589
ICCV 03203	2158	3361
ICCV 03302	1881	2632
ICCV 03403	2264	2373
ICCV 03406	1351	2989
ICCV 03407	2584	2426
ICCV 04103	2658	3348
ICCV 04110	2119	2596
ICCV 04111	1917	2726
ICCV 04301	1472	2043
ICCV 04303	1726	2884
ICCV 04304	2158	2793
ICCV 04306	2542	3202
ICCV 95311	1787	2650
ICCV 97024	1951	2512
ICCV 97306	2484	2510
ICCV 97314	2193	2709
Karachi	2242	1894
PCHL 04-2	2391	2326
PCHL 04-32	2271	2668
PCHL 04-34	2600	2400
PCHL 04-5	2985	2611
Shwenilongi	2129	3605
Yezin 3	1918	2754
Yezin 4	2119	2731
Yezin 5	1631	1578
Yezin 6	2082	2966
ZCHL 05-2	2616	3701
ZCHL 05-20	2164	2807
ZCHL 05-73	2341	2003
ICC 4958 ©	2675	2526
Mean	2236	2725
$LSD_{(0.05)}$	748	844

Relative Water Content (RWC): Significant differences for RWC were observed among chickpea genotypes under rainfed and irrigated conditions (Table 1). The heritability of RWC was good due to the genetic variation of RWC. Under rainfed condition, nine genotypes were observed as promising genotypes for high RWC. The highest RWC was observed in ICCV 00108 (86.03%) followed by Yezin 6 (85.84%), Yezin 5 (85.61%) (Table 3). However, no consistency results were obtained under irrigated condition due to an interaction of genotype x environment.

Correlation between seed yield and drought tolerance traits: Correlations between seed yield and drought tolerance traits provide information on expected responses in seed yield from selection for drought tolerance traits. In the present study, a significant positive relationship was observed between seed yield and SCMR (r = 32 at p <0.05) under rainfed condition (Table 4). A negative correlation was found between SLA and SCMR (r = -0.16 and -0.18) and RWC (r = -0.08 and -0.05) under rainfed and irrigated conditions, but not significant.

Lower seed yield, higher SCMR, lower SLA and RWC indicated that rainfed condition suffered from more moisture stress to certain extent than irrigated conditions. In this study, the adverse effect of moisture stress on seed yield was clearly evident by its lowest value in the rainfed conditions with a reduction in terms of 18 per cent in comparison with irrigated conditions. The yield reduction can be ascribed to statistically retarded performance with respect to various yield attributes especially pods per plant and biomass yield (data not shown). However, the reductions in seed yield could not be observed in ICCV 03107, PCHL 04-5, Karachi, ZCHL 05-73, ICCV 01303, PCHL 04-34, ICCV 03407, ICC 4958, PCHL 04-2 and Yezin 5. It indicated that these genotypes may have inbuilt capacity to resist moisture stress effectively.

The present study has also shown that, ICCV 03110, ICCV 00108 and ICCV 04110 showed superior and more consistent SCMR values than the others. Besides, ICC 4958 is a well known drought resistant genotype had better SCMR. It was possibly due to its strong root systems (Kashiwagi *et al*., 2006). The SCMR is an indicator of the photosynthetically active light transmittance characteristics of the leaf, which is dependent on the unit amount of chlorophyll per unit leaf area (Chlorophyll density) (Richardson *et al*., 2002). Leaf photosynthesis is generally correlated with chlorophyll content per unit leaf area and hence the SPAD chlorophyll meter reading can provide a useful tool to screen for genotypic variation in potential photosynthetic capacity under drought conditions (Nageswara Rao *et al*., 2001).

Although SLA was reduced by drought stress, SLA in certain genotypes under rainfed was dependent on that under residual moisture conditions. ICCV 04303, ICCV 03302, ICCV 04301 and ICCV 01303 showed consistently lower SLA than other genotypes in both rainfed and irrigated conditions. In addition, the high seed yielding genotype PCHL 04-5 showed lower SLA than ICC 4958 under the rainfed conditions. The variation and consistency of SLA make it useful for the application as a selection criterion in drought tolerance breeding program.

The low value of RWC was recorded under rainfed conditions, which might be due to the impact of lower soil moisture supply. According to Reddy *et al*. (2003), biochemical components in leaves of stressed plants were changed although the plants could maintain RWC as high as those for non-stressed plants and RWC in a range lower than 85% is considered severely stressed. In the present study, the mean value of rainfed condition for RWC was 78.97 %. Thus, the tested chickpea genotypes faced moisture stress as a terminal drought. Similar findings were reported by Arunyanark *et al*. (2008), who found significant differences for RWC between drought treatment and control treatment as early as 33-35 days after withholding water. According to this result, ICCV 00108, Yezin 6 and Yezin 5 had the highest RWC and may be assumed as promising genotypes for high RWC for drought tolerance.

Table 3. Drought tolerance trait of chickpea genotypes under rainfed(R) and irrigated (I) conditions at ICRISAT during post-monsoon season, 2009-2010

Genotypes	SCMR		SLA		RWC	
	R	I	R	I	R	I
Annigeri	65.49	58.92	291.5	306.3	75.40	93.19
ICCC 37	67.08	58.12	243.1	287.3	84.92	82.92
ICCV 00108	69.05	66.78	186.4	205.9	86.03	80.89
ICCV 00401	62.11	60.19	194.8	236.6	72.65	89.19
ICCV 01303	63.33	60.80	160.3	207.0	81.22	79.65
ICCV 03103	66.06	57.34	182.4	234.6	80.05	83.15
ICCV 03107	63.27	56.02	227.5	261.1	76.68	72.62
ICCV 03110	70.07	65.03	267.9	271.3	80.06	78.80
ICCV 03111	67.21	59.88	215.7	232.2	77.76	73.01
ICCV 03203	67.31	62.22	176.0	201.5	75.88	80.28
ICCV 03302	63.42	63.14	157.0	217.8	77.55	88.72
ICCV 03403	65.32	61.29	257.3	218.2	80.33	75.28
ICCV 03406	62.01	61.10	175.6	192.8	76.22	76.67
ICCV 03407	65.21	63.50	221.9	193.6	76.46	80.71
ICCV 04103	65.40	59.96	216.9	247.4	70.69	77.00
ICCV 04110	67.41	63.39	183.8	260.7	78.79	82.04
ICCV 04111	66.24	60.08	172.3	254.5	73.23	70.90
ICCV 04301	64.15	61.40	158.1	216.5	82.19	80.89
ICCV 04303	63.39	59.69	150.8	200.9	77.30	95.85
ICCV 04304	62.74	57.05	228.1	216.2	83.45	81.01
ICCV 04306	64.13	64.49	172.4	193.7	80.53	87.41
ICCV 95311	64.11	58.35	252.2	271.3	69.66	78.99
ICCV 97024	66.11	60.88	273.7	282.6	79.96	84.16
ICCV 97306	65.86	57.38	223.8	252.5	77.86	85.21
ICCV 97314	66.41	59.25	197.5	204.5	80.75	85.87
Karachi	65.64	57.70	228.3	236.8	80.49	81.00
PCHL 04-2	68.03	61.16	173.9	244.6	78.12	82.88
PCHL 04-32	62.60	61.55	194.0	188.8	82.42	79.51
PCHL 04-34	62.43	56.49	212.1	201.7	76.97	86.19
PCHL 04-5	66.08	60.26	185.1	267.7	79.86	78.88
Shwenilongi	67.30	60.05	214.3	217.0	81.97	76.01
Yezin 3	59.85	57.00	189.1	238.6	80.05	76.70
Yezin 4	63.01	59.93	259.3	221.5	75.99	82.92
Yezin 5	61.03	57.52	232.0	185.3	85.61	81.03
Yezin 6	66.56	60.92	184.9	258.7	85.84	82.00
ZCHL 05-2	66.42	60.72	249.7	267.7	78.93	78.08
ZCHL 05-20	66.16	62.20	226.5	218.1	81.36	80.23
ZCHL 05-73	57.99	58.23	196.2	211.3	81.99	86.83
ICC 4958 ©	68.15	62.28	209.7	229.9	74.47	79.51
Mean	64.98	60.32	208.8	232.2	78.97	81.44
$LSD_{(0.05)}$	3.85	4.14	50.5	48.7	7.17	10.08

Table 4. Correlation coefficients between seed yield and drought tolerance traits of chickpea genotypes under rainfed and irrigated conditions at ICRISAT during post-monsoon season, 2009-2010

Traits	Seed Yield (kg ha^{-1})	SCMR	SLA	RWC
Seed Yield (kg ha^{-1})				
Rainfed	-			
Irrigated	-			
SCMR				
Rainfed	0.32*	-		
Irrigated	0.17	-		
SLA				
Rainfed	0.29	-0.16	-	
Irrigated	0.25	-0.18	-	
RWC				
Rainfed	-0.07	0.02	-0.08	-
Irrigated	0.05	0.00	-0.05	-

*, Significant at the $p \leq 0.05$

Differential responses of genotypes for drought tolerance traits indicated that several drought resistance mechanisms might exist. Combining these characters in chickpea breeding programs should increase drought resistance in chickpea. In this study, SCMR was significantly correlated with seed yield under rainfed conditions (Table 4). Similar positive correlation between SCMR and seed yield has earlier been reported in groundnut (Nageswara Rao *et al*., 2001). Higher SCMR seems to be an indication of the genotype's capacity for higher carbon assimilation and in turn seed yields even under moisture-limited situations. Significant and positive correlation between SCMR and

chlorophyll content was observed and SCMR was also closely related with chlorophyll density (Nageswara Rao *et al*., 2001). A positive correlation was found between seed yield and SLA under rainfed and irrigated conditions (Table 4). A negative correlation was found between SLA and SCMR under rainfed and irrigated conditions (Table 3). Similar relationship between SLA and SCMR has been reported in groundnut (Upadhyaya, 2005). Genotypes with lower SLA (thicker leaves) are known to have more of photosynthetic machinery, i.e. more chlorophyll content (Nageswara Rao and Wright, 1994). Moreover, negative correlations were also found between SLA and RWC under rainfed and irrigated conditions. This indicated that genotypes with thicker leaves may have more RWC under drought conditions.

Among drought tolerance traits (SCMR, SLA and RWC) SCMR had the highest correlation with seed yield and the measurement of SCMR was easy and simple. Moreover, these traits have lower G × E interaction than do SLA and RWC. It would be possible to improve yield by selecting high SCMR. Thus, the SPAD chlorophyll meter provides an easy opportunity to integrate a surrogate measure of WUE with seed yield, in the selection scheme of a drought tolerance breeding program in chickpea.

Acknowledgements: We thank all the staff at ICRISAT for their technical support and friendship. Valuable advice and experimental support by Dr. L. Krishnamurthy (Physiologist, ICRISAT) and Dr. Z.A. Mainassara (Physiologist, Niger) is greatly appreciated.

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J. Agrofor. Environ. 11 (1 & 2): 83-88, 2017 ISSN 1995-6983

Cost and benefit of summer paddy cultivation in Myaungmya township: case study on three different farming practices

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Abstract: This paper tries to present difference farming practices and their returns in summer paddy cultivation in Myaungmya Township. Nearly ninety percent of monsoon paddy cultivated areas are occupied by summer paddy due to having access to irrigation sources, higher return and less risk. In summer paddy cultivation, three different farming practices are found and these are different in investment, knowledge on paddy cultivation and farmers' interest on paddy cultivation. Some farmers cultivate paddy by using agriculture machineries and chemical inputs and other use farm machineries but farm mechanization is still in its incipient stage. The cost of machinery use and chemical fertilizer increased the investment in paddy cultivation but farmers get high yield. Seed producers cultivate paddy systematically to get quality seeds. They use sufficient amount of chemical fertilizers and pesticides systematically. Smallholders do not use sufficient amount of chemical fertilizer due to less investment. Smallholder farmers mainly cultivate summer paddy to get food for household consumption and to sell small amount of surplus. Labour cost is highest in the cost of paddy cultivation due to labour shortage and labour intensive work. At present, the amount of loan from Myanmar Agriculture Bank has been raised but it is still insufficient for actual cost of paddy cultivation due to high labour cost and high price of chemical fertilizers, pesticides and others. Productivity and returns of the intensive farmers and seed producers differ from those of smallholders. Cost-benefit analysis and benefit-cost ratio were done to explain the findings.
Key words: Different practices, inputs, productivity, cost-benefit analysis.

Introduction

Rice is the most important cereal crop of Myanmar and it remains as a strategic sector in terms of its continuing significant contribution to Gross Domestic Product (GDP), income and employment generation.Total population of Myanmar was recorded as 51.4 million in 2014, an increase of 148% from 21.5 million in 1960 (World Bank, 2014). To meet the basic food need, paddy cultivated areas were extended and paddy is cultivated not only in monsoon period but also in cool and hot dry period.

Farmers have became aware that summer paddy gives high yield because of high sunshine intensity and summer paddy cultivation is of less risk. The cultivation period is free from untimely rain and it is cultivated in dry period with the help of irrigation. One of the most important requirements related to paddy cultivation is irrigation (Panuju *et al*., 2012). Because part of the Deltaic area, there are many streams and the existing streams networks are an advantage for summer paddy cultivation in the area.

Ayeyarwady region is known as rice granary of Myanmar and Myaungmya Township is one of the townships in Ayeyarwady region. Summer paddy cultivated area occupied 90 percent of the total rain fed paddy cultivated area, yield per unit area of summer paddy is higher than that of monsoon paddy and risk is lesser than that of monsoon paddy. Farmers extensively cultivate summer paddy but farming practices differ from one another. Three farming practices in summer paddy cultivation are found and their returns are also different.

Ramachandra and Nagarathna (2000) said that agriculture requires three major resources, land, water and energy. Land, being a resource, agricultural productivity could be linked directly to the availability of water (rain or irrigation) and energy inputs. The capital requirement in agricultural production depends on many factors in which type of product produced, the production level, technology used, geographical condition, input used, the demographical characteristics of the farmer, and etc. Input used in paddy cultivation is directly related to paddy productivity. The farmers who systematically used sufficient amount of chemical inputs get high yield. In the area, intensive farmers and seed producers use higher capital investment than the smallholder farmers.

Availability of quality seed is one of the major constraints inincreasing the productivity of agricultural crops (Hoque and Haque, 2014). Use of quality seed can increase productivity of paddy. In the study area, it is difficult to get quality seed for farmers and seeds are produced by the local farmers under the guidance of staff of agriculture department. The farmers are interested in paddy cultivation and they cultivate paddy systematically to get qualified seeds. They use sufficient inputs which cost high investment. But, the seed producers get higher return due to higher price of quality seeds for cultivation.

All farmers do not operate at the same efficiency level. Investment and interest of farmers differ from one another in adapting and using the knowledge and technologies to their own farms to get high return. FAO (1981) stated that increased agricultural productivity usually come as a result of effective adoption of improved technologies. Wortman and Cumming (1978) also expressed that one of the requirements that increase the productivity is input. Fertilizer use and fertilizer price became more important issue in Agriculture especially paddy cultivation. In developing countries, actual application rates of fertilizer are low, and it is well below those recommended in some countries in Asia (FFTC, 2008). Intensive famers and seed producers are more interested in paddy cultivation to get high yield.

In the area, some famers are poor and they do not have sufficient investment to cultivate paddy systematically. Since the government stopped selling these chemical fertilizers at reasonable prices to the farmers since 1994, the farmers cannot apply the necessary amount because of high prices at private shops (Lwin, 2014). They use chemical fertilizer below the recommended level.

Tun (2014) stated that most of agricultural lands are currently cultivated by small scale farmers and the cost of land preparation and cultivation is rather high and productivity is low. In the area, more than half of the farmers are smallholders and their capital investment for

paddy cultivation is low. Therefore, productivity is low and they get low return.

The objectives of the paper are to understand the reasons that cause different cultivation practices, to explore different farming techniques, and to find out different returns from summer paddy cultivation and to forecast the future prospects of summer paddy cultivation in the area.

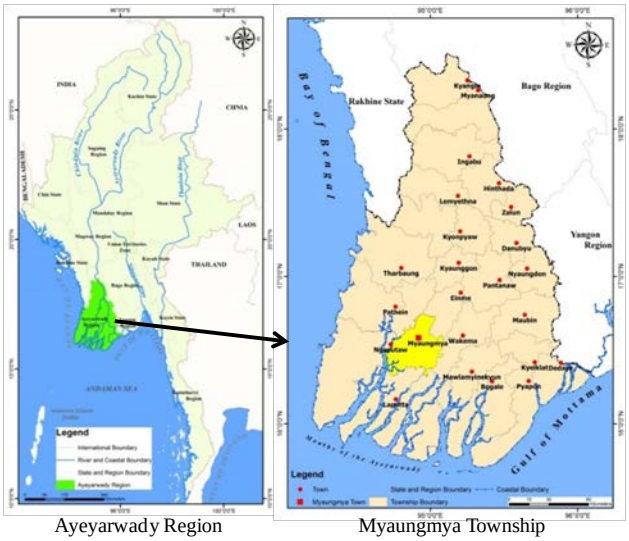
Materials and Methods

To present this paper, primary and secondary data were applied. To get primary data, 9 village tracts among the 98 village tracts were selected as sample villages and field surveys were done during summer paddy cultivation period between December and April in 2015. Three farmers from each village tract were interviewed to get thorough understanding on summer paddy cultivation. Primary data such as inputs, capital investment and labour use, price, returns, etc were collected by using questionnaires. To present net return of summer paddy cultivation, cost benefit analysis, benefit-cost ratio were applied. Secondary data were also applied to present spatial distribution of summer paddy cultivated area and they are obtained from departments concerned.

Results and Findings

Factors Supporting Summer Paddy Cultivation: Basic geographic factors such as location, topography, drainage, climate and soils support summer paddy cultivation in Myaungmya Township. Moreover, farming methods, inputs and irrigation have significant influence on the productivity of summer paddy.

Physical Factors: Physical factors such as relief, drainage, climate and soils directly or indirectly influence summer paddy cultivation of any area.



Ayeyarwady Region Myaungmya Township

Fig. 1. Study area (Ayeyarwady Region and Myaungmya Township) in Myanmar; Source: Agriculture Atlas (2002)

Location: Myaungmya Township is located in the southwestern part of Ayeyarwady Region and it lies between North latitudes 16°19´ and 16°44´ and also between East longitudes 94°40´ and 95°05´(Fig. 1). Bay of Bengal is about 69.19 km (43 miles) in the west and Kappali (Andaman) Sea is about 104.59 km (65 miles) in the south (Myint Myint Win, 2014). The area of Myaungmya Township is 1,152.23 sq.km (444.88 sq-miles) or 3.28 per cent of Ayeyarwady Region. The township comprises 12 wards (urban) and 98 village tracts.

Relief and Drainage: The study area is located on the Ayeyarwady deltaic region built up with alluvium. The lowland region is composed of alluvium with an elevation of less than 7.62 m (25 ft) above the mean sea level. It is almost a flat plain (Fig. 2). The most significant feature of the landscape is the braiding network of river and streams. The widest plain is found along the Ywe River and the area is very suitable for summer paddy cultivation.

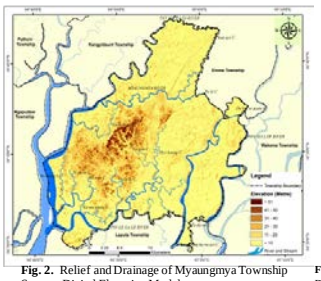


Fig. 2. Relief and Drainage of Myaungmya Township
Source: Digital Elevation Model

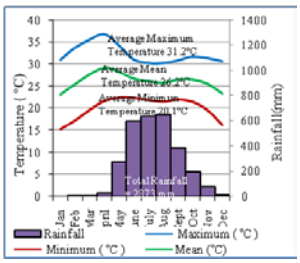


Fig. 3: Climograph of Myaungmya Station (1981 to 2010)
Data Source: Meteorology and Hydrology Department, Myaungmya

The major rivers are Panmawady, Myaungmya, Pyamalow, Ywe, Pinlegalay and Pathein (Ngawun). Panmawady, Pyamalow, Ywe and Pathein rivers are distributaries of Ayeyarwady River and flow from north to south. Pya Creek flows through the northern part of the township, Kyonton, Kangyi and Pulu creeks through the northeastern part of the township. Except the rivers located in the southernmost part of the area, most streams support irrigation water for summer paddy cultivation.

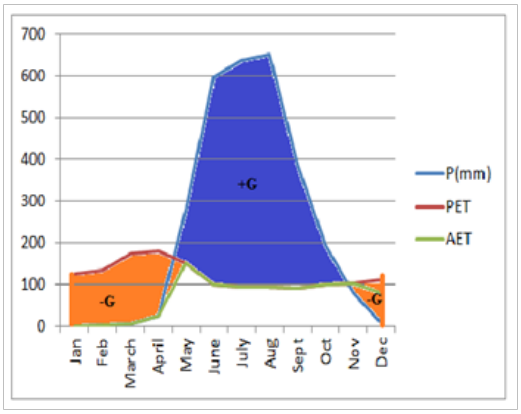
Climate: According to Koppen's climatic classification, with more than 18° C (64.4°F) of the coolest month temperature and an annual rainfall of over 2,800 mm (112 inches), the climate type of the study area is Tropical Monsoon (Amwg).

Climate directly controls agriculture including summer paddy cultivation. The annual mean temperature is 26.2° C (79.61°F). The hottest month is April with a mean monthly temperature of 29.2° C (84.56° F) and January the coolest month with 23.1°C (73.58° F). The mean monthly maximum temperature is highest in April with 36.8° C (98.24° F) and lowest in July and August in 30.2° C (84.36° F) due to cloudiness of the sky and it slightly decreases in the cool dry period from November to January and rises up to 35° C (95.9° F) in the hot dry season from March to third week of May. Paddy is extensively grown in the area because the optimum temperature for rice cultivation is between 25°C and 35°C (Ghadirnezhad and Fallahads**,** 2014).

Rainfall is highly seasonal with a considerably long dry period from November to the end of May (Fig. 3). Water requirement is high for summer paddy cultivation because of high temperature and scarce rainfall in the hot dry period. Summer paddy is grown with the help of irrigation.

Water Balance: In the area, ground water recharge is found until November and December. Then, from January to April, water deficit occurs (Fig. 4). Therefore, it is difficult to grow paddy in dry season without irrigation. Myaungmya Township possesses several rivers which support irrigation water for summer paddy. Therefore,

paddy is grown from January to April with the help of irrigation.



P = Precipitation, PET = Potential Evapotranspiration, AET = Actual Evapotranspiration , G– = Ground Water Utilization, G + = Ground Water Recharge

Fig. 4. Water Balance of Myaungmya Township
Source: Meteorology and Hydrology Department, Yangon

Soils types: The existing soils support paddy cultivation and more than 80 percent of the area is suitable for paddy cultivation because of the presence of meadow soils (Fig. 5).

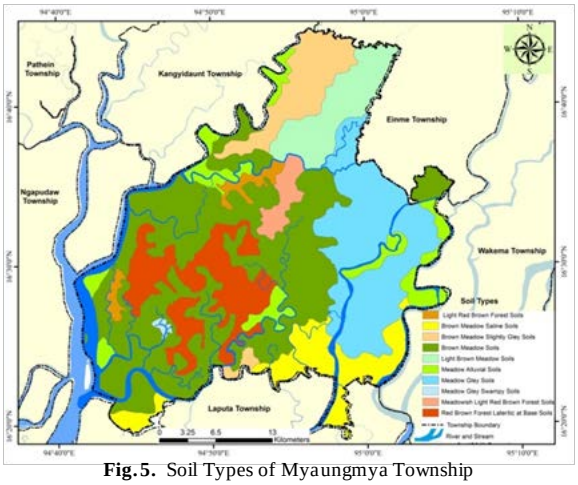


Fig. 5. Soil Types of Myaungmya Township
Source: Land Use Department, Yangon

Rural Urban Population: Generally the number of rural or urban population unfolds the major economic activity of the area. In 2015, total population was 298637 persons of which urban population was 44795 persons (15 per cent) and rural population 253841 persons (75 per cent) (Fig. 6). It shows that most of the population lives in the rural area and depends on agriculture.

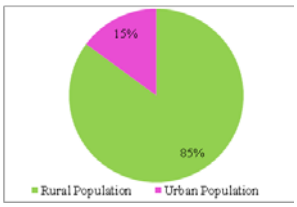


Fig. 6: Urban and Rural Population of Myaungmya

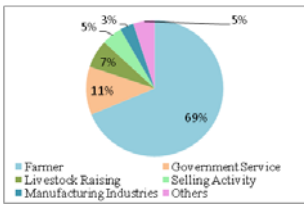


Fig. 7. Labour Force of Myaungmya (2010-11)

Source: Immigration , Man Power and Man Power Department, Myaungmya

Labour Force: Sixty nine percent of the populations are engaged in agriculture. This shows the importance of agriculture sector in the economy of the township (Fig. 7).

Spatial Distribution of Summer Paddy Cultivated Area: Summer paddy is grown successfully only in areas where irrigation water is available. Therefore, summer paddy cultivation is mainly found on the farmlands proximate to the river and streams such as Myaungmya, Ywe, Panmawady and Pyamalow.

The large sown area of summer paddy is found near rivers and streams that supply large amount of water to irrigate the farmlands. The village tracts with large sown area of summer paddy were Hpayarchaungahsugyi, Mwaytawshansu, Thazinkonegyi, Bamawthonegwa, Kantharkone, Kywechanpaykone, Lutaw and Kywetnwechaung village tracts. Irrigation water is available for these village tracts due to nearness to Myaungmya, Ywe, Panmawady and Pyamalow rivers, Laputkular and Theinlar creeks, etc (Fig. 8).

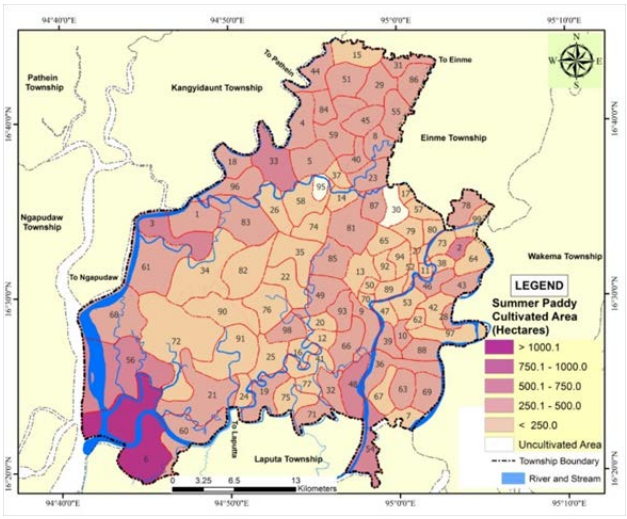


Fig. 8: Summer Paddy Cultivated Area in Myaungmya
Source: Data base, Land Records Department

Productivity of paddy varies with farming practices in the area. Intensive farmers and seed producers get higher productivity than smallholders due to different input uses and different farming practices. Average productivities of intensive farmers was100 baskets per acre, that of seed producers and smallholder farmers 90 baskets per acreand 60 baskets per acre respectively.

Different Farming Practices and Cost-Benefit Analysis on Summer Paddy Cultivation: In Myaungmya Township, 95 per cent of the farmers cultivate summer paddy on more than 90 per cent of the monsoon paddy cultivated area. Three different farming practices are found in the area and farmers in these groups are intensive farmers, seed producers and smallholder farmers.

First farming practice is done by intensive farmers who own summer paddy cultivated area of more than 20 ha (50 acres) cultivating systematically and carefully (Table 1). They have much investment and use much input in paddy cultivation. Farmers in the first group are rich and they have sufficient investment. They use agriculture machineries in paddy cultivation to be completed in time and sufficient inputs guided by the staff of Agricultural

Department. But, they practice broadcasting method in summer paddy cultivation because of labour shortage.

Table 1. Cost-benefit in Summer Paddy Cultivation (Intensive Farmers)

Items	Cost/acre (ks)	%
Tillage (machine)	15000	4.8
seed (8000 ks ×3.5 baskets)	28000	9.1
Shwenagar weedicide	18500	6.0
Urea 2 bags	40000	13.1
T super 2 bags	30000	9.8
labour cost	100000	32.7
Diesel cost	15000	4.9
Others	20000	6.5
Harvesting	40000	13.1
Total cost	306500	100
Return (100 baskets ×6000 ks)	600000	
Net benefit	293500	

Source: interview (2015)

They use agriculture machinery in plowing. They mainly use hand-pushed tractors which are made in China. The value of it is about 2,000,000 kyats (more than 1500 US$) and some farmers hire agriculture machinery from the Richs and agricultural company. A hand-pushed tractor takes only 8 hours to plough a farm with an area of a hectare. Rental cost is 20000 ks per day (more than 15 US$ per day). Diesel cost is 5000 ks per acre (nearly 4 US$ per ha). To drive it, labour cost is 5000 ks per day(about 4 US$ per day). Therefore, the total cost of plowing is about 15,000ks (nearly 13 US$ per acre). They usually till their land twice to get high yield in paddy cultivation.

They cultivate high yield varieties because they have sufficient investment and they intend to get higher yield per unit area. Quality seeds are more expensive and the price is 8500 kyats per basket (185 kyats per lb). Fora hectare of paddy field, 3.5 baskets are needed to apply. Generally, more seeds are needed in broadcasting method. Most famers use 2.5 baskets per hectare but intensive farmers use larger amount to get more productivity

Chemical inputs uses differ from one farmer to another. At the stage of tilling, they use weedicide to kill weeds. Shwenangar brand weedicide is most popular in that area and they use 2.5 bags per ha (one bag per acre) to protect the field from weeds. Price of a bag of Shwenangar weedicide is 18500 kyats. They also apply chemical fertilizers according to guidance of the agriculture staff. They use 2 bags of Urea and 2 bags of T super per acre in summer paddy cultivation.

Labour cost includes costs of plowing, harvesting, pumping water and spraying pesticides. Although machineries are extensively used in plowing, manual labour is still mainly used in harvesting, pumping water and spraying pesticides. In harvesting, human labour is manly applied due to tall paddy plants. Average labour cost is 4000 kyats per day and total labour cost is round about 100,000 kyats per acre.

Pumping cost varies from one place from another because of different soils. In some places, soils are sandy and such soils need more water. Generally, water is irrigated three times before harvesting. They irrigate 5 or 6 times depending on the soils. The cost of diesel is about 5,000 kyats per acre (nearly 4 US$) at the first time. The cost for first time irrigation is higher because water requirement is higher at the first time. Therefore, total diesel cost is 15,000 kyats per acre. Diesel cost differs from one farmer to another because of existing soils. It is necessary to irrigate water at least 5 times on loamy soil but 7 times on sandy soils. Among the cost of cultivation, labour and input costs are higher and they are the chief causes that produce high yield.

The total cost is 306500 ks per acre and productivity of paddy is 100 baskets per acres. In 2015, price of paddy was about 6000 ks per baskets. Therefore, farmers get high benefit and they get 293500 kyats per acre due to high productivity which is resulted from high investment.

In the second type, the farmers cultivate summer paddy for selling seeds to the farmers in the area and to other areas (Table 2). They follow guidance of the staff of agricultural department exactly to produce quality seed. They are very interested in paddy cultivation.

Table 2. Cost-benefit in Summer Paddy Cultivation (Seed producers)

Items	Cost/acre (ks)	%
Tillage (machine)	15000	3.7
seeds (10000 ks ×2 baskets)	20000	4.8
Fungicide & Pesticide	20000	4.8
Potash 0.5 bags	13000	3.1
Urea 1.5 bags	30000	7.3
T super 1 bags	20000	4.8
Harvesting	60000	14.5
labour cost	200000	48.4
Pumping cost	15000	3.6
Others	20000	4.8
Total cost	413000	100.0
return (90 baskets × 9000 Ks)	810000	
Net benefit	397000	

Source: interview (2015)

Cost of cultivation is larger than that in the first group. To produce quality seed, farmers till the land thoroughly and the cost is also high. Therefore, cost of labour, rental cost of agriculture machinery and diesels costs are higher in land preparing stage.

Fertilization cost ranks as the third highest cost after labor and mechanization costs. In fact, input costs represent 22.37 percent of the total cost. Farmers mainly use Urea, Potash and T-Super. Farmers usually apply the macro-nutrients as granular fertilizers, and the micro-nutrients as liquid are applied together with the pesticides. They use chemical fertilizer two times: first time is at 21 days and second time at 50 days after cultivation. With granular fertilizers, nitrogen is the most important nutrient for rice production and the urea is the most used fertilizer because it is composed of 46 percent of nitrogen although the portion of urea actually used by rice plants is very low (Vargas, 2012). Farmers in this group have large amount of capital investment and they know systematic seed producing technology and use farms inputs. But the uses vary one farmer to another depending on their drainage and soils. They use more inputs to get higher seed production.

They cultivate high yield quality seed to get high quality seeds. They need nearly 2 baskets per acre. Amount of seeds used is lower than that used in first group. They practice transplanting method in which systematic method

(6 inches × 8 inches apart) is applied. Although the number of plants in an area is lower, the production and seed quality is higher due to sufficient nutrients and systematic planting. Price of seeds for cultivation is higher than seeds for consumption because of high quality seeds. Price of seeds is about 10000 kyats per basket.

Labour cost is much higher than that of intensive farming because of systematic cultivation. Systematic cultivation method needs much amount of labour and it takes more time in cultivation. They cultivate paddy plant along the string line to be systematic. It costs much because of high labour requirement cost and the small holders cannot practice the method due to high labour cost. They cost more on planting and harvesting. One permanent laborer is hired for year round to be engaged in not only for on-field activities but also for supplementary work in the farm enterprise such as farmland plot maintenance, water management, storing and others. Total labour cost for one acre is about 200,000 kyats for the production of summer paddy seeds. The labour costis high because it is necessary to care the paddy filed continuously. Threshing machines are widely utilized in the village for paddy andpulses to save the time and reduce post-harvest loss. However, harvesting is done manually.

The productivity is 90 baskets per acre. The price of seeds for cultivation is usually higher and it was about 9000 kyats per basket in 2015. Although the seed producers cost much investment, they get higher price and higher net income. Therefore, farmers get high benefit and their average net return is 397000 kyats per acre due to high productivity which is resulted from high investment and price.

In the third group, the farmers cultivate summer paddy for the purpose of getting household consumption and selling (Table 3). But, they do not have sufficient investment and they cannot afford to buy sufficient amount of inputs. They use less amount of input and get low yield.

Table 3. Cost-benefit in Summer Paddy Cultivation (Smallholder farmers)

Items	Cost/acre (ks)	%
Tillage (manual)	15000	6.7
seed (8000ks ×3.5 baskets)	28000	12.6
Pesticide	10000	4.5
Urea 1 bags	20000	9.0
T super 1 bags	20000	9.0
Harvesting	40000	17.9
labour cost	80000	35.9
Diesel cost	10000	4.5
Total Cost	223000	100.0
return (60 baskets ×6000ks)	360000	
Net return	137000	

Source: interview (2015)

Agriculture machinery is used in this group to till the land. They usually practice broadcasting method and only two labours are needed for seeds broadcasting. Therefore, labour cost is low in seed broadcasting period. Total labour cost is about 80,000 kyats. Most of the farm works are done by family members.

Agriculture bank has been disbursed the loan for paddy cultivation with the rate of 100,000 kyat per acre since 2011and interest rate is 5 percent. But, the farmers who own more than 10 acreget only 1,000,000 kyats. The loan is available during the period from April to August for monsoon paddy and from September to December for summer paddy. But, it is insufficient for paddy cultivation. Moreover, they use less input. Authorities concerned guide to use 2 bags of urea per acre, but most farmers in the group use 1.5 bags per acre of urea and1 bags of t-super though the authorities instruct to use 2 bags of t-super per ha. They do not use sufficient amount of input to reduce the cost of input and capital investment. It affects yield per unit area and it gives low return.

Burma, Syria, Argentina, Kenya, Australia and India use less than 30 kg of nutrient per ha of arable land (FAO,1981). Farmers in the area try to produce quality seeds. But, now, amount of input use increased in paddy cultivation but it is still under recommended level due to low investment.

They do not use weedicide because they practice traditional methodto reduce capital investment. Family members remove weeds for reducing labour cost. Diesel cost is about 10,000ks per acre. Their net benefit is137000 kyats per acre.

Seed producer get highest productivity as they cultivate paddy systematically under the guidance of the agriculture staff and they use sufficient chemical input to get quality seed.

Benefit Cost Ratio: According to calculation proposed by Husssin *et al.,* (2008), the value of Benefit Cost Ratio (BCR) of intensive paddy cultivation, seed production and smallholder farmers' paddy cultivation are 0.95, 0.96 and 0.61respectively. As More and more the value of Benefit Cost Ratio, more will be the net return and intensive farmers and seed producer get more return. It unfolds that the farmers who are interested in paddy cultivation, they use sufficient amount and have high investment and get higher return.

Conclusion

In Myaungmya Township, farmers know the effects of untimely rain and irregular rain at the end of monsoon period and they cultivate summer paddy extensively due to water availability from nearby streams and free from negative impacts of climatic irregularity. In the study area, three different farming practices are found and the intensive farmers and seed producers differ in cultivation method, input use, productivity, investment and interest of smallholder farmers. Depending on their farming practices and investment, they get different return. Labour and input cost are high among the cost of cultivation. The intensive farmers and seed producers use much amount of input by using large capital investment and they get high yield and high return. Smallholder farmers who do not have sufficient investment use fertilizer under recommended level and they get low yield.

Benefit Cost Ratio **(**BCR) also shows that smallholder farmers get low return. In the study area, nearly half of the farmers do not have sufficient capital investment and they are in vicious debt cycle because they have to borrow money for paddy cultivation from the money lenders with high interest rate.

Authority concerned needs to plan to offer sufficient loan for smallholders. It is also needed to distribute the new

knowledge and technologies to those who practice unsystematic paddy cultivation methods and persuade to practice systematic cultivation by supporting necessary aids such as agricultural machinery, investment and modern farming techniques. The intensive farmers and seed producers use chemical fertilizers which cause environmental deterioration and the fertilizer use will almost certainly rise in the future. Therefore, continuous farmer education is necessary to make them understand new paddy cultivations methods and input uses, to get high yield and to reduce environment impacts on paddy cultivation. It is necessary to do researches on price fluctuation, environmental impacts on paddy cultivation and soil deterioration to achieve sustainable development in summer paddy cultivation.

Acknowledgements: This paper has been prepared during the stay of Myint Thida as a visiting scholar of the CSEAS (Center for Southeast Asian Studies, Kyoto University) Fellowship for Visiting Research Scholars 2016 from Nov. 1 2016 to Jan.31.2017 Accordingly, the authors would like to acknowledge institutional supports of Department of Geography, University of Yangon, Myanmar and CSEAS, Japan for conducting the field work and paper preparation. Our thanks also go to the villagers from the study area for their participation during our filed work.

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J. Agrofor. Environ. 11 (1 & 2): 89-96, 2017 ISSN 1995-6983

The effect of drought and the selling of cultivated farmlands on the livelihood of local farmers in Bagan-Nyaung U area

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Abstract: A case study was carried out to identify the impacts of drought and tourism development on reducing farmlands and the contribution of household income in Bagan-Nyaung U area. Recurrent droughts in the study area caused lower crop productivity and forced the local farmers to sell their farmlands for livelihood. During the same period, tourism developmental activities in study villages also stimulated the local farmers to sell-off their farmlands due to higher demand and market prices. Thus, reduction in per capita cultivated farmlands provided the opportunity towards participation in non-farm livelihood activities. Based on the primary household survey, the average annual household incomes were marginally higher among farmland-sold households when compared with non-sold households. The farmland-sold households have chosen a new development pathway by pursuing nonfarm-based livelihood strategies as ways to mitigate their dependency on farmland. These households over time tend to increase their durable asset base and mean household consumption expenditure patterns per annum. The reductions in farmland due to drought and tourism development have improved their household welfare by motivating them to take part in diverse non-farm livelihood opportunities. Non-sold farm households whose are completely dependent on agriculture for livelihood did not improve their standard of living in the study area. This clearly indicates the declining profitability of agriculture and increased dependency on non-farm livelihood opportunities. These findings are aptly reflecting the existing trends in many developing countries in South Asia. (232 words).
Key words: Durable assets, households' income, impact of drought, reducing farmland, tourism development.

Introduction

Bagan-Nyaung U area is one of the richest archaeological sites because it is the place of the ancient city where thousands of Buddhist monuments (temples, stupas, monasteries, etc.) located. It is situated in the central dry zone (CDZ) of Myanmar. The typical characteristic features of the central dry zone region are erratic rainfall, higher temperatures, sandy soils with low fertility and poor water-holding capacity. Majority of people living in this zone depend on agriculture and allied activities for their livelihood. The unit agricultural productivity is declining over time due to frequent droughts and erratic monsoon situation in Bagan-Nyaung U area. The strategy to improve further agricultural production in the zone consists of improved irrigation facilities, adaptation of climate change mitigation strategies, bringing more land under cultivation and advocating crop diversification through enhanced cropping intensity.

Bagan-Nyaung U area is severely affected by consequent droughts in which the average annual rainfall is often lower than normal rainfall over decades (data of Dry Zone Agricultural Research Farm, Nyaung U, 2003-2015). Since the region chronically receiving a lower quantum of rainfall compared to the other parts of Myanmar, farmers are surviving with unstable livelihood opportunities with little or negligible prospects of increasing agricultural production. According to Myanmar's National Adaptation Programme of Action (NAPA), the central dry zone is one of the most vulnerable to climate change (UNEP, 2012). The annual household agricultural incomes were not enough to meet their household expenses because of frequent experiences of crop losses. The negative deviations in household earnings from agriculture have threatened farmers' livelihood security and forced them to sell their farmlands. Thus, farmers started reducing their area allocation under different crops in the study area.

In addition, Bagan-Nyaung U area is one of the prime destination places for tourism in the country. Due to the implementation of social and economic reforms in the early 2011, tourism has developed rapidly in Bagan-Nyaung U area and resulted in significant expansion of urban area and hotel constructions. The rapid urbanization has invaded and occupied the available farmlands in the vicinity. Due to that significant arable land has been diverted to non-agricultural purposes in the selected villages. The increased urbanization is also associated with a decline in agricultural land-use and intensity (Jiang *et al*., 2013). Urbanization also created huge pressure on arable land and this inturn increased the unit farmland prices along the road side. The farmers were self-motivated to sell-off their farmlands due to higher market prices.

Frequent crop failures due to drought have led to unaffordability of land for cultivation and continue future agriculture investments. The rising unit land prices were negatively impacted farmers, who no longer can afford to grow crops on these lands. Agriculture plays an important role in poverty alleviation and food security in Myanmar rural areas. But farming became not an adequate source of household income for all categorizes of farmers regardless of its size. Majority of the farmers from rural areas tried to move away from agriculture for their livelihood. Thus, the farmers in the study villages tend to sell their farmlands because of lower margins in cultivation. Negative impacts of farmland loss (due to urbanization and industrialization) have been found in China (Chen, 2007) and India (Fazal, 2000). The positive impact of farmland loss on rural livelihoods was noticed in China (Johnson, 2002) and Bangladesh (Toufique and Turton, 2002). The mixed impact of farmland loss on rural household livelihoods was not attempted so far in the literature (Tuyen *et al*., 2014). Therefore, the present study made a humble attempt to identify these impacts of drought and tourism development on reducing farmlands in Bagan-Nyaung U area of Myanmar Particularly the impact of selling farmlands on farmers' livelihood.

Materials and Methods

A case study was carried out in three villages, namely, Phyauk Seik Pin, Kun Sin Key and Tek The in Nyaung U Township. These villages are located at the southern edge of Nyaung U Township. On an average, these villages are located six kilometers away from Nyaung U Township (Fig. 1). A purposive random sample of 50 households were identified from the three villages and interviewed for the present study. The sample was post-stratified into farmland-sold households and non-sold households to minimize the bias in the selection. Data was collected with a structured questionnaire which was developed based on the study objectives and extensive review of the literature. The survey instruments were prepared highlighting the concerns of households relating to drought and agricultural activities, household characteristics, sources of household income, composition of household assets, and household expenditures etc. The primary data were collected from the selected households in the three study villages. Secondary data on historical rainfall was also collected from Dry Zone Agricultural Research Farm. The land use change data over time were also obtained from Settlement and Land Records Department, Nyaung U Township. Both descriptive statistic tools and independent T-test were applied to check whether there is a significant difference in the means among two-category (farmland-sold and non-sold households) of farmers.

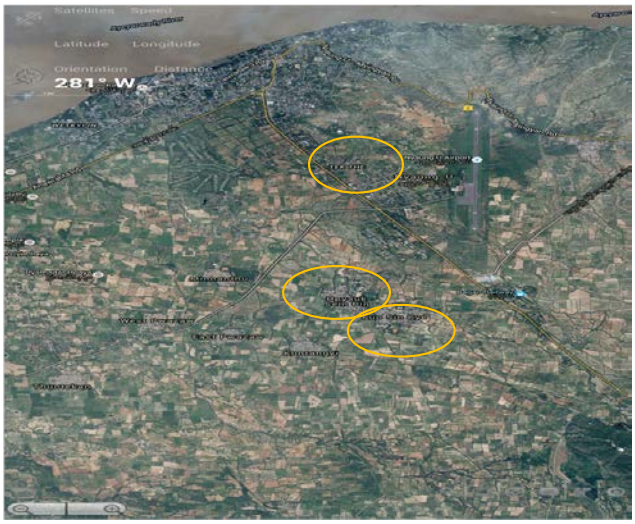

Figure 1. Phyauk Seik Pin, Kun Sin Kye and Tek The village locations in Nyaung U Township.

Results

Socio-economic profile of sample: The socio-economic characteristics of sample households in the study area are categorized into farmland-sold households and non-sold households and summarized in Table 1. Male headed households are slightly dominated in case of farmland non-sold households when compared with farmland-sold households. Relatively, the average educational levels (no. of years of education) are better in case of non-sold household than sold household group. The mean farm size per household and household head experience in agriculture was marginally higher in case of farmland non-sold household sample than the farmland-sold households. In both the groups, all the sample households indicated that farming is their primary occupation and livelihood. Majority of farmland-sold households availed the loan facility and their average borrowed amount is much higher than the other group of farmers.

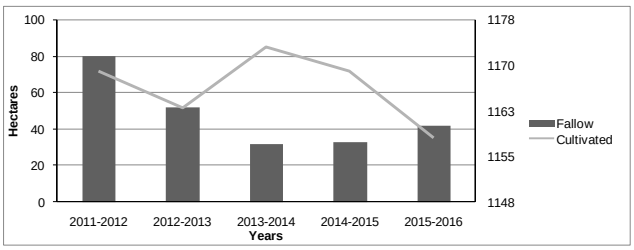

Figure 2. The relationship of cultivated and fallow upland area in Kone Dan Gyi village track during 2011-2012 to 2015-2016. Source: Settlement and Land Records Department, Nyaung U Township

Land sharing and utilization patterns in study village: The study areas were in Kone Dan Gyi village track and Tek The village. Phyauk Seik Pin and Kun Sin Kye villages are included in Kone Dan Gyi village track. The land utilization particulars data collected during the last six years from the study villages are summarized in Table 2. In Kone Dan Gyi village track, the cultivated area trend was decreased while the fallow area was increased between 2011-2012 and 2015-2016 (Fig. 2). The increased urbanization (areas allocated to road, pond, canal and stream) was observed over a period of time. The rapid urban area expansion is due to the recent policy support and encouragement from government. Development of tourism industry in Bagan-Nyaung U area was also another major factor for declining farmlands per household.

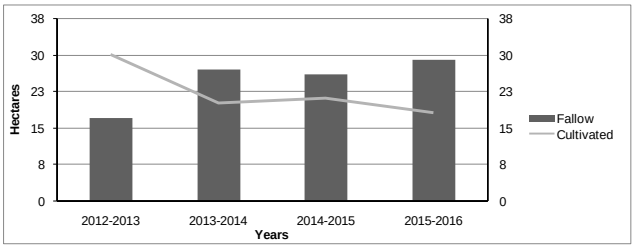

Figure 3. The relationship of cultivated and fallow upland area in Tek The village during 2012-2013 to 2015-2016.

Land sharing and utilization pattern details of Tek The village is also presented in Table 2. The cultivated area was nearly decreased to one-half while the area under fallow has gone-up significantly (Fig. 3). There were only ten farmers growing crops for their livelihoods. The main reason for significant decline in cultivated area was farmers were not willing to cultivate the crops. They have shifted their livelihood options from farm to non-farm activities in the village. Majority of village area was moved away from agriculture to non-agricultural purposes due rapid urbanization of Nyaung U Township. The socio-economic characteristics were changed in Tek The village from being fully dependent on agricultural activities

towards non-farm activities. The differential impacts arise from the inappropriate regulation exerted in agricultural land and interrelated to poverty (El-Hefnawi, 2005).

Table 1. Socio-economic characteristics of household heads

Items		Variable	Sold households (N=32)	Non-sold households (N=18)
Gender of Head	Male	25	15	
	Female	07	03	
Age of Head	< = 50 years	08	04	
	51-60 years	10	05	
	61-70 years	10	06	
	> 70 years	04	03	
Education level (completed years)	< 5 years	17	11	
	> 5 years	15	04	
Major occupation	Farming	32		18
	Non-farming	0		0
Farm size (hectares)	< = 4.0 ha	15		07
	4.1 -8.0 ha	11		08
	> 8.1 ha	06		03
Loan facility availed	< = 20 years	07	03	
	21-40 years	14	06	
	> 40 years	11	09	
Loan facility availed	Yes	25		12
	No	07		06
Size of loan amount (Kyats)	< = 100000	08	04	
	> 100000	17	08	

Source: Result of survey data (2016)

Table 2. Land use (hectares) in study area during 2011-2012 to 2015-2016

Village	Years	Upland	Fallow	Station	Road	Pond, canal & stream	Village	Airport	Religion	Others	Total
Kone Dan Gyi village track	2011-2012	1169	80	22	65	125	46	20	177	27	1731
	2012-2013	1163	52	25	70	125	53	30	185	28	1731
	2013-2014	1173	32	24	73	127	53	30	193	26	1731
	2014-2015	1169	33	24	73	127	53	30	196	26	1731
	2015-2016	1158	42	24	73	127	53	30	198	26	1731
Tek The village	2012-2013	30	17	5	17	64	36	23	12	3	206
	2013-2014	20	27	5	17	0	100	23	12	3	206
	2014-2015	21	26	5	17	0	100	23	12	3	206
	2015-2016	18	29	5	17	0	100	23	12	3	206

Source: Settlement and Land Records Department, Nyaung U Township

Droughts in the study area: Bagan-Nyaung U area is the central core of dry zone and affected by desertification and droughts in which the average rainfall levels are noticeably below than that of normal (Fig. 4). Mean annual rainfall in the dry zone is lower than the rest of the country, ranging from 500 to 1000 mm (IWMI, 2015). Bagan-Nyaung U area has been experiencing climate variability effects over decades. Thus, the central zone of Myanmar is highly vulnerable to drought as compared to other parts of the country (UNEP, 2012).

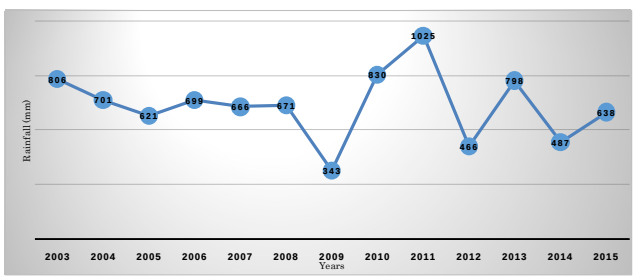

Figure 4. Annual rainfall over a period of 2003 to 2015 at Dry Zone Agricultural Farm, Nyaung U Township. Source: Dry Zone Agricultural Research Farm, Nyaung U Township.

The precipitation pattern in the Bagan-Nyaung U area can be characterized as a bimodal one, with an early rainy season and a late rainy season occurring (Fig. 5). The rainy starts from May/June and extends to September/October. The bimodal rainfall pattern favors a double cropping system for the study area, meaning that farmers can grow twice on the same plot each year, and in which a second crop is planted after the first is harvested. There was a longer period of the dry spell during June/July. The average monthly temperature ranged from a minimum of 13°C to a maximum of 40°C between 2003 and 2015. Bagan-Nyaung U area is often recorded as the hottest place in Myanmar where a maximum temperature touches up to 43-44°C in April/May.

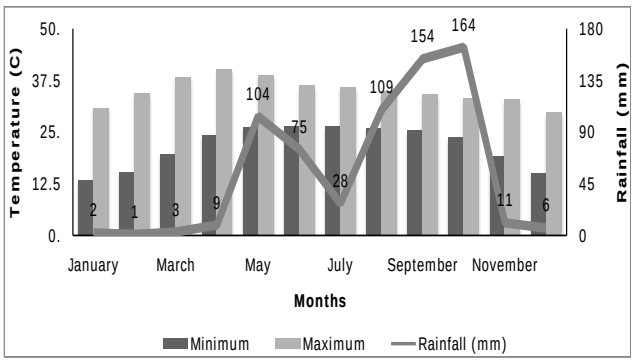

Figure 5. Average temperature and rainfall over a period of 2003 to 2015 at Dry Zone Agricultural Farm, Nyaung U

Township. Source: Dry Zone Agricultural Research Farm, Nyaung U Township

Drought occurs mostly in the early rainy period due to prolonged dry spells and shortage of soil moisture. This situation adversely affects the crop productivity in the study villages. Particularly, in Bagan-Nyaung U area drought years have significant adverse effects on the production of crops, leading to food shortages for both man kind and livestock in the region.

Table 3. Shifts in cropping systems (hectares per household)

Major crops	Area sown (ha)
Past (decade ago)	
1. Runner groundnut (*Virginia*)	2.71
2. Sesame (*in early rainy*)	1.30
3. Mungbean	0.61
4. Cucumber mixed kitchen crops	0.45
5. Erect groundnut (*Spanish*)	0.65
6. Sorghum	1.46
7. Mungbean+Pigeonpea	0.04
8. Sesame (*in late rainy*)	0.85
Present (2016)	
1. Runner groundnut (*Virginia*)	2.63
2. Mungbean+Pigeonpea	1.34
3. Cucumber mixed kitchen crops	0.16
4. Erect groundnut (*Spanish*)	0.16
5. Sorghum	0.77
6. Sesame (*inlate rainy*)	1.34

Source: Result of survey data (2016)

Shifts in cropping systems: Major shifts in cropping systems in the study area over a decade period are summarized in (Table 3). Runner groundnut (*Virginia type*) was the dominant crop observed both in the past and present situations. It is preferred because it adapts well to the severe drought conditions. Groundnut is mainly grown for home consumption (*cooking oil*) and draft feed (*crop stubbles*) for livestock purposes. To minimize the risk in cultivation, recently, farmers tend to cultivate groundnut as intercrop with other crops. The area allocation under crops such as sesame (*sown in early rainy season*) and erect groundnut (*Spanish type*) was reduced because of climatic aberrations and lack of assured returns.

The extent of area allocation and choices of crops are highly determined by the pattern of on-set and quantum of rainfall received. The sample farmers also opined that the traditional/local varieties have higher tolerance to mitigate the drought than modern/improved cultivars. However, improved varieties of mungbean and pigeonpea are preferred for obtaining higher productivity levels. Farmers always optimize their resource allocation under scarce situation to attain the maximum profit from their cultivation.

Average productivity levels: Overall, the sample farmers' perceived that the average productivity levels of crops were lower now than one decade ago (Table 4). Farmers experienced poor harvests about three times out of last seven years, where the yields were approximately half of a good harvest or even less (Matsuda, 2016). Sample farmers expressed that timely precipitation is essential for obtaining good harvest. Insufficient rains decline the crop growth during the early rainy season. The dry spells occur during June/July further aggravate this situation. Matsuda (2016) concluded that poor or negative returns from agriculture might have accounted for significant rural poverty in the central dry zone. The sample farmers also opined that they tend to do limited investments on crops due to high risk and uncertainty. This also might be another important reason for low adoption of crop improved production technologies and low crop productivity.

Table 4. Farmers' perceptions on productivity of major crops

Crops	Average yield (kg/ha)		
	Normal yield	Good yield	Bad yield
Runner groundnut	314	548	227
Sesame (*in early rainy*)	304	756	183
Erect groundnut	314	783	NA
Mungbean	435	914	156
Pigeonpea	435	484	170
Sesame (*in late rainy*)	277	371	121
Sorghum- (grain)	692	976	346
(fodder)	12 ton	16 ton	8 ton

Source: Result of survey data (2016)

Table 5. Changes in farmland holding sizes during the five years period

Items	Variables	Distribution (N=50)
Changes in land holdings	Yes	38 (76%)
	No	12 (24%)
Reasons for land holdings changing	Land sold	32 (84%)
	Land given	6 (16%)
Reasons for sale of land	Not fit for agricultural cultivation	12 (31%)
	Fetches higher prices	14 (37%)
	For livelihood	6 (16%)
Average how many hectares sold	Hectares/household	2.63
Average how much unit price	Hectare/ hundred thousand Kyats	623.2

Source: Result of survey data (2016), ** Significant at 10% level

Changes in farmland holding sizes: Cultivated land holding changes were noticed in nearly about 76% of study sample households during the five years period (Table 5). The remaining 24% sample households indicated that there were no changes in their farmland holdings. The survey data also points that nearly 84% of the total farmland holding changes were occurred due to sale of cultivated lands while another 16% were given land to non-agricultural uses i.e., airport, station, road, and canal. The reasons of land sale were various such as not fit for cultivation due to drought and poor soil (31%), fetching higher market price (37%) and for livelihood (16%). On an average, 2.63 hectares of farmland per household was sold by sample farmers with a unit price of 623.2 hundred thousand Kyats per hectare. It is a remarkable decline in average farmland holding during the span of five years. In general, the land prices were much higher in the peripheries and on the road side. Selling small parcels of farmland was more attractive to sample farmers than the agricultural crop incomes in the study villages (Arandel and El-Batran, 1997; El-Hefnawi and Madbouly, 2001).

Table 6. Households' income

Items	Net income per year (hundred thousand Kyats)			
	Sold households (32)	%	Non-sold households (18)	%
Crops	20.5	20	16.7	18
Agricultural wages	1.0	1	0.3	
Non-agricultural wages	7.0	7	2.6	3
Salaries	6.9	7	7.4	8
Self-employment	33.6	33	38.9	41
Rental taxi	6.2	6	12.4	13
Interest from savings	25.6	26	16.3	17
Mean of households' income	100.7		94.5	
Standard deviation	118.1		132.5	
Std. Error Mean	20.8		31.2	
T-test value		-.172*		

Source: Result of survey data (2016), ** Significant at 10% level

Table 7. Comparison of households' assets of farmland sold and non-sold households

Items	Unit	Sold households (32)	Non-sold households (18)
Cultivated land	Hectares	5.71	7.13
Draft animals	%	65	72
Cow/cattle	%	13	5
Thresher	%	6	5
Gold	%	78	61
Motor car	%	44	33
Motorbike	%	91	83
TV	%	25	11
Fridge	%	13	11
Mean of households' assets (hundred thousand Kyats)		4044.6	2258.6
Standard deviation		4269.7	1585.9
Std. Error Mean		754.7	373.8
T-test value		-1.703**	

Source: Result of survey data (2016), ** Significant at 10% level

Contributions of households' income: The farmland-sold households, on an average, earned higher annual household income (100.8 hundred thousand Kyats) than non-sold households (94.6 hundred thousand Kyats) (Table 6). Data analysis revealed that farmland-sold households obtained a large income (33%) from self-employment (*like a business*), followed by interest earnings from saving (26%) and crops cultivation (20%). The non-sold households obtained incomes from self-employment (41%), followed by crops cultivation (18%) and interests from saving (17%). In general, self-employment includes small business, shops, tailoring, bricks lying, carpentry as well as trading etc. The data clearly reveals that self-employment is more important source of household income for rural households than crops cultivation. Thus, most of the farmers in the study area are attempting to diversify their sources of household income for their livelihood. In household economics, diversification is identified as one of the best risk minimization strategy of households often adapted by dryland farmers in Semi-Arid Tropics (Walker and Ryan, 1990). Even though there was a significant difference in annual household incomes between two categories of farmers, it is not statistically significant among them.

The average earnings from savings and interests were relatively higher in farmland-sold households than non-sold households. The farmland-sold households could be investing higher on inputs and management which in-turn gave better returns from agriculture. The incomes generated from wages in agriculture and non-agriculture sources were about 8% in farmland-sold households while it was only 3% in non-sold households. This clearly implies that the family members of farmland-sold households tend to participate more in different jobs to maximize their earnings.

Household assets: The survey results summarized the status of household assets of farmland-sold and non-sold households in Table 7. On average, farmland-sold households have relatively less farmland (5.71 hectares) than non-sold households (7.13 hectares). With regards to

extent of draft ownership, farmland-sold households have a lower level (65%) compared with non-sold households (72%). The lower level of draft ownership implies that few farmers sold their draft animals because of reduced farmland holdings. But the extent of investments on other durables (motor car, motor bike, TV and fridge) was much higher in case of farmland-sold households than other category. The unit purchases on gold also relatively higher in case of farmland-sold households. The data clearly implied that the farmland-sold households increased their quantum of durables assets by selling of their farmlands. There is significant difference in the total household asset ownership between these two groups. The differences between them also proved to be statistically significant at 10% level. The extent of household assets indicates both the welfare and credit worthiness of the household. The results of the present study also concluded that farmland-sold households have informal employment structure and they tend to spend more on durable assets to improve their standard of living.

Table 8. Household consumption expenditure

Items of expenditure	Distribution of household expenditures (%)	
	Sold households (32)	Non-sold households (18)
Rice	24.0	24.6
Cooking oil	16.0	15.5
Non-vegetarian food (meat)	12.8	11.8
Health	9.6	15.0
Education	15.2	12.3
Ceremonies	22.4	20.9
Mean of expenditure (hundred thousand Kyats/year)	30.7	27.3
Standard deviation	13.4	13.5
Std. Error Mean	2.4	3.2
T-test value	-.863*	

Source: Result of survey data (2016), ** Significant at 10% level

Table 9. Comparison of offerings and other factors across groups

Items	Distribution of other social factors (%)	
	Sold households (32)	Non-sold households (18)
Donations		
Waso robes	63	61
Kathina ropes/Shinbyu	78	50
Built/renovated religious purpose	56	17
Mean donation (hundred thousand Kyats/year)	10.3	4.9
Standard deviations	5.7	5.2
Std. Error Mean	1.0	1.2
T-test value	-3.33***	
Others		
Housing facilities	41	5
Saving to bank	22	11
Acquired to car	28	5

Household consumption expenditure: Average household consumption expenditure of farmland-sold households and non-sold households are summarized in Table 8. Overall, the total annual household expenditure was slightly higher in case of farmland-sold households than non-sold households. On average, nearly 24% and 16% of total household expenditure was spent by both category of households respectively on rice and cooking oil in the study area. The unit expenditure on non-vegetarian food (meat) was slightly higher in case of farmland-sold households than other category.

Regarding on non-food expenditure, lower amount of health expenditure (9.6%) was observed in case of farmland-sold households compared with non-sold households. However, the expenditure on education in farmland-sold households (15.2%) was higher than non-sold households (12.3%). Similar trend was also observed in case of annual expenditure on household ceremonies. These trends clearly visualize the move towards an improved welfare situation of farmland-sold households than non-sold households in the study villages. Even though there was a marginal difference in total household expenditures between two categories of farmers, it is not statistically significant.

Other social factors: Qualitative data on donations (*ahlu*) were also collected during household interviews to estimate the total donations offered by the sample farmers in a particular year. These details across two categories of farmers are summarized in Table 8. Almost all the sample households were offering donations to Buddhist images or monks in the study villages. The normal donation items are depend on Myanmar calendars such as offering robes to Buddha images; to the Buddhist monks (*Waso robes, Kathina robes*); and offering variety of food stuff and gifts to the aged and *Shinbyu* ceremonies etc. Although the same proportion of *Waso robes* donations were observed between two category of farmers, *Kathina robes andShinbyu* ceremonies were significantly higher in case of farmland-sold households. *Kathina robes andShinbyu* ceremonies are generally more costly that enables to donate only by well-off households. Specific donations on built/renovated religious purposes were also significant higher in case of farmland-sold households than other group.

On the whole, a total donation in a year offered by non-sold households was estimated about 4.9 hundred thousand Kyats. The farmland-sold households offered donations at least two to three times higher (10.3 hundred thousand Kyats per year) than their counterparts. It is also observed that farmland-sold households donate more not only in terms of total amount per annum but also in frequency (*no. of times per annum*) than non-sold households. The data results clearly implied that the social impact of farmland-sold households was much more than non-sold households.

In addition to offering, other factors of housing facilities and acquiring of number of motor cars have also increased in case of farmland-sold households (Table 9). Overall, the results of the household survey indicated that the selling of farmlands have improved the living standard of farmland-sold households to a certain extent. Instead of using bamboo or toddy palm leaves roof houses, sampled households started to live in tin shed and brick wall houses and they could also afford to buy motor cars as tangible assets. The access to increased assets in farmland-sold households exhibited enhanced alternate employment

opportunities in the study area. This has ultimately helped them to improve their livelihood options over time.

Discussion

Bagan-Nyaung U area, itself has unlikely weather conditions such as high temperature, scare rainfall etc. Drought is the natural event there. Even though the local farmer tended to grow their crops as per usual under this climate uncertainty, as agriculture is the main source of income. The dominant cropping is runner groundnut which adapted to the severe drought conditions. The cultivation of sesame in early rainy season is becoming less because climatic fluctuations have become more intense with frequent droughts in early rainy season and rainfall patterns changing. The study area currently has becoming more to the intercropping of mungbean and pigeonpea in order to ensure production from at least one crop as insurance against unreliable rainfall. JICA (2013) reported that farmers always consider how to get higher farm income by choosing varieties with higher price and suitable crop varieties to cope with scarce and fluctuating rainfall.

According to the household interviews, the average productivity of cultivated crops has decreased and fluctuated widely. The choice of crops and cropping systems mainly depends on rainfall in the study area. Farmers stated that timely precipitation is essential and insufficient moisture for crops growth during the early rainy season and dry spell in June/July led to lower yield. Matsuda (2016) pointed out that low agricultural productivity and occasional poor harvests due to the unreliability of rainfall might account for rural poverty in the central dry zone.

The lower incomes from agricultural work have threatened farmers' livelihood security and forced them to sell the farmlands and depend on different income sources for their survival. In addition, Bagan-Nyaung U area is one of the main destinations for tourism. The demanding in hotel construction which caused to raise farmland prices and stimulates to the local farmers for selling. There were more households who sold farmlands as fetching higher farmland price and personal financial need.

According to the survey, the farmlands-sold households tend to have a higher level of annual household income than non-sold households. Self-employment or business is identified as a dominant source of total household income in the study area. In addition, others income generating activities such as rental taxi and interest from saving are perceived to be contributed significantly to improving the standards of living. The results of the study showed that more than half of their incomes derived from other sources, though agriculture remains the major source of rural income for the farmers. Thus, the single source income of agriculture not covered for their account for livelihoods in the study area. The natural tendency of rural households to engage in multiple occupations is very commonly noticeable in the study area. This indicates that income diversifications were observed on households through farmland sold, participation in wages and interest earnings from deposits etc. The dependency on multiple enterprises diversifies their sources of household income and minimizes the negative deviations in total earnings.

The differences in household assets were observed between these two groups of households. On average, farmland sold households has substantially less farmland and a lower level of draft ownership compared with non-sold households. The farmers in the study area have reduced their land and livestock assets over a period of time due to the decrease in crops cultivation and rapid urbanization. However, the farmland-sold households tend to increase the durable assets such as gold, motor cars, motorbikes, TV, and fridge etc. In every asset category studied, farmlands-sold households have acquired more items than non-sold households. This is evident through the selling of farmlands and investing more on the durables assets. According to the primary survey, most of the farmers have sold their farmlands and moved out of agriculture such as rental taxi for tourist, self-employments/business. Some prefer to save in physical asset of gold and cash deposits in the bank. Nem Nei Lhing *et al*. (2010) pointed out that household savings can provide protection against risks and also provide opportunities to expand the existing economic activities. The results of the present study also concluded that farmlands-sold households have informal employments structures and they tend to change to alternative employments very easily.

In addition, the farmland-sold households tend to increase their households' consumption expenditures and more participate in donation activities. As previously discussed, changes in livelihood choices towards nonfarm activities may be a way to raise rural household welfare. These nonfarm activities, however, are not sure to sustain for farmers in future. Agriculture is crucial in terms of employment, food security and budgetary allocation, even though the share of agriculture income has decreased in the study area. Therefore, agricultural activities should be promoted through the distribution of agricultural inputs such as improved seeds and fertilizers, more economic crops and better extension services delivery in order to boost agricultural production.

Conclusion:

Recurrent droughts in Bagan-Nyaung U area forced the local farmers to sell-off their farmlands and diversify their income earning opportunities towards non-agriculture. Due to high risk and uncertainty in agriculture, the total cultivated area in the selected villages as well as the mean per capita farmland holdings were reduced over time. The primary household survey has revealed significant changes in landholding during the study period. Non-viability of agriculture and the development of tourism activities have immensely contributed to this shift. The farmers have started diversifying their earning opportunities from agriculture to non-agriculture and minimizing the risk. The share of non-farm income in the total household income has started increasing while contribution from agriculture is losing its ground.

The data analysis has clearly concluded that mean annual household income was slightly higher (6.6%) in case of farmland-sold households than non-sold households. Even though it is not statistically significant marginal difference between these figures were observed. The average

earnings from agriculture, savings in bank and wage incomes have contributed for enhanced incomes in case of farmland-sold households. The increased participation in the informal sector not only helped the farmland-sold households to mitigate negative consequences of land loss but also opened-up a new avenue of livelihood opportunities. This has clearly helped these households to improve their durable asset structure and annual household consumption expenditure. The changes in average household assets were significantly different (at 10% level) between two category of farmers. However, the variations in annual household consumption expenditures were not statistically significant. Additionally, farmland-sold households were also actively participated (significant at 1% level) more in donation activities. Overall, the findings aptly support the rural transformation of Myanmar from farming to non-farming sectors and increased dependency on non-farm employment opportunities.

Acknowledgements: This paper has been prepared during stay of Mar Mar Win as a visiting scholar of the CSEAS (Center for Southeast Asian Studies, Kyoto University) Fellowship for Visiting Research Scholars 2016 from Oct 1 2016 to Dec.31.2016. Accordingly, the authors would like to acknowledge institutional supports of Department of Agricultural Research, Myanmar and CSEAS, Japan for conducting the field work and paper preparation. Our thanks also go to the farmers from the study area for their participation during our field work.

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J. Agrofor. Environ. 11 (1 & 2): 97-102, 2017 ISSN 1995-6983

Tourist industry and its impact upon socio-economic development of Bagan-Nyaung U area

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Abstract: Tourist industry is one of the main economic activities of Bagan-Nyaung U area which are important for socio-economic development for that region. Tourist industry is one of the important sources for earning foreign currency and creating job opportunities. Tourist industry and tourism related businesses are main encouraging factors in the economic development of Bagan-Nyaung U area. Number of hotels, restaurants and souvenir shops are main businesses related tourism.
Key Words: Business, socio-economic development, souvenir shops, tourist industry.

Introduction

Many scholars defined the term "Development" from various aspects. Dale (2000) mentioned "Development is a broader and more diverse concept, denoting improvements in the quality of life of people, extending much beyond direct gains from increased production of commodities and services".

Social and cultural integration emerges along with the national integration process. " Socio-cultural integration" is a process of integration of existing culture and historical heritage with the social system for the use of promotion tourism, arts, crafts, music, songs and cultural dance into economic benefits. Therefore, the socio-cultural integration has large externalities on cultural, tourism, art and craft, exports and finally regional development.

After 1988, the government of Myanmar has been making all round effort for the parallel development of all the regions across the Union. Myanmar formally declared 1996 as Visit Myanmar Year and launched activities for tourism development in 1994, attention of the most people drawn on the country. Bagan (formerly Pagan), an ancient city, is situated in the Nyaung U District. It was a birth place of Myanmar's Civilization that developed in the eleventh century.

In ancient city of Bagan and surrounding areas, the impact of tourism was the revival of social and cultural life of the people through tourism. The increasing number of tourists provided social and economic opportunity for the locally produced goods and revival of artisanship. As Bagan is famous for ancient treasure and lacquerware, the improvements of tourism have a large positive impact on the existing industry.

Materials and Methods

The Study area: The study area, Nyaung U District included within the Mandalay Region in the Central Dry Zone of Myanmar (Fig. 1). The district consists of Nyaung U Township and Ngathayauk sub-township. It comprises 16 wards, 75 village tracts and 223 villages, covering 572.755 square miles of an area. In this district, Bagan is a famous tourist site not only for international tourists but also for local visitors.

Methodology: This study is intended to examine the relationship between economic activities and social conditions within Nyaung U District. In order to measure relationship and association, statistical methods (correlation and regression, fluctuation and trend, factorial design and cluster analysis) will be applied.

Interviews and field surveys are an intensive as well as an extensive examination of socio-economic development, using face-to-face interviews and questionnaires. Detailed information was obtained from some key informants by open interviews. Mapping, data linkage and analysis were done by Geographic Information System (GIS) technique, with the help of topographic maps, aerial photographs and photographs.

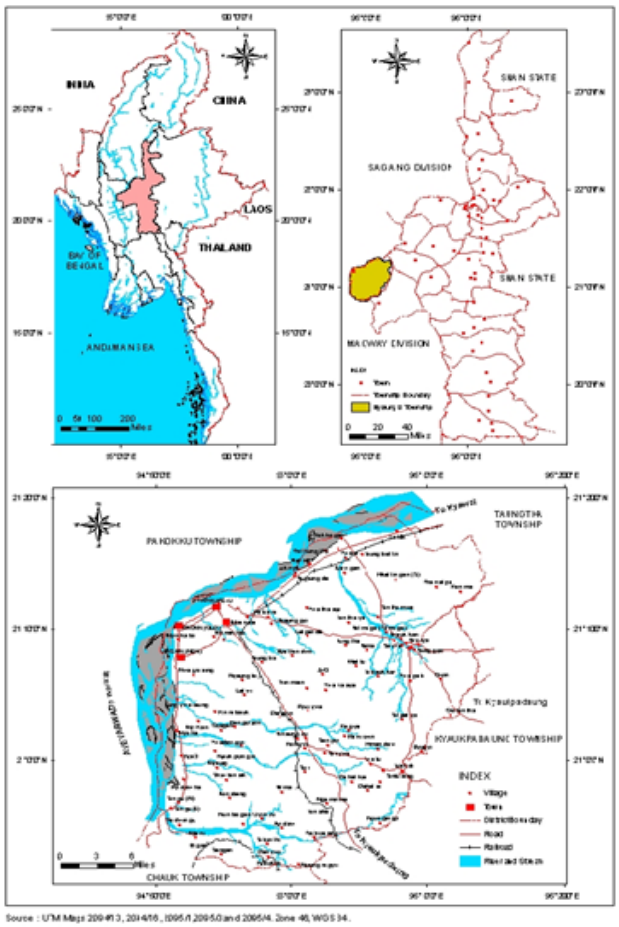

Fig. 1. Map 1 Location of Bagan-Nyaung U area

Results and Discussion

Due to the growth of tourist arrivals in Bagan area, number of hotels, restaurants and souvenir shops are gradually increasing in number and size. There are significant growth of hotels in Bagan-Nyaung U between 1972 and 2010. There was one hotel in 1972. Hotel and guest houses were gradually upgraded for increase number of tourist arrivals. After 1996, which is demarcated as Visit Myanmar Year, hotel zones were built to develop tourist industry. In the hotel zone, 27 hotels, 21 guest houses, and 3 motels were constructed after 1996. In recent period, there are 40 hotels, 27 guest houses, 5 motels, 2 resorts and 2 inns in Nyaung U area (Table 1).

Table 1. Hotel, Motel, Inn and Guest House of Bagan-Nyaung U (1972-2010)

No	Year	Name of Hotels, Motels, Inns and Guest House	No	Year	Name of Hotels, Motels, Inns and Guest House
1	1972	Thiripyitsaya Sakura Hotel	39	1996	ThiriSanda Hotel
2	1978	Aye Yar Hotel	40	1996	Yun Myo Thu Motel
3	1992	Goldern Express Hotel	41	1996	Sonseya Motel
4	1994	Aung Mingala Hotel	42	1996	Ayeyar River View Hotel
5	1994	Glorious Bagan Guest House	43	1996	Duwun Hotel
6	1994	Diamond Egale (1) Hotel	44	1996	Ingyin Hotel
7	1994	Kaday Aung Hotel	45	1996	Nan Eain Thu Hotel
8	1994	Lucky Seven Guest House	46	1996	Thande Hotel
9	1994	New Wave Guest House	47	1996	May Khalar Guest House
10	1994	Goldern Myanmar Guest House	48	1996	Smile World Hotel
11	1994	Mya Sein Dipa Guest House	49	1996	Zagawa Palace Hotel
12	1995	Bagan Hotel	50	1996	View Point Guest House
13	1995	Blue Bird Hotel	51	1996	Bagan Princess Guest House
14	1995	Kumudara Hotel	52	1997	Union (2) Hotel
15	1995	Kyi Kyi Mya Guest House	53	1997	Myanmar Treasure Hotel
16	1995	Mya Pui Sone Guest House	54	1997	Bagan Central Hotel
17	1995	New Park Guest House	55	1997	Kyaw Guest House
18	1995	New Heaven Guest House	56	1997	Goldern Pot Guest House
19	1995	Pann Cherry Guest House	57	1997	Shwe Nagar Hotel
20	1995	PyinsaRupa Guest House	58	1997	YarKhinTha Hotel
21	1995	Winner Guest House	59	1997	New Bagan Inn
22	1995	Zar Chi Win (2) Hotel	60	1997	Myanmar Hotel
23	1995	Oasis Guest House	61	1998	Bagan Golf Resort
24	1995	Myat Bagan Hotel	62	1998	Bagan ThiriZarni Hotel
25	1996	Inn Wa Guest House	63	1999	Mya KanTha Motel
26	1996	Eden Motel (1)	64	1999	ShweTaung Tan Hotel
27	1996	Kaytumadi Dynasty Hotel	65	1999	Ruby True Hotel
28	1996	Lawkanat Hotel	66	1999	Goldern Village Inn
29	1996	Mya Thida Guest House	67	2000	Arthawka Hotel
30	1996	New Life Guest House	68	2000	Eden (2) Motel
31	1996	N.K Betel Nut Hotel	69	2000	Tampawadi Hotel
32	1996	Pagoda City Hotel	70	2000	Family Guest House
33	1996	Prince Guest House	71	2001	Greenwich Hotel
34	1996	Silver Moon Hotel	72	2003	Tharabargate Hotel
35	1996	Nyaung U Thande Hotel	73	2004	ShweNadi Guest House
36	1996	San YeikNyein Guest House	74	2004	Mahanadi Guest House
37	1996	Thazin Garden Hotel	75	2005	Diamond Egale (2) Guest House
38	1996	Thiri Marla Hotel	76	2006	Aureum Palace Resort

Source: Ministry of Hotels and Tourism, Bagan (1996)

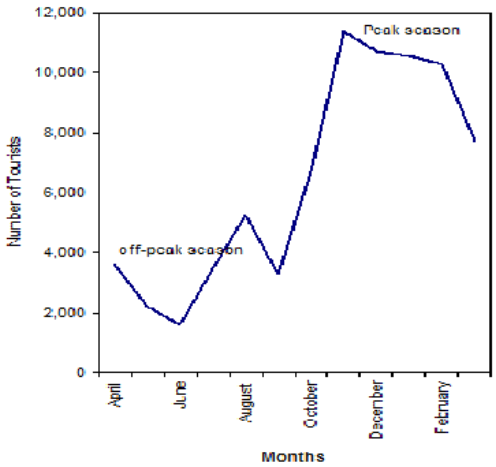

Fig. 2. Seasonal Tourist Arrival of Bagan-Nyaung U (2010) (Soe Thint, 2010).

According to 2010 statistics, there are 1368 workers engaged in hotels which are related to tourism. Therefore, tourism created job opportunities and gave knowledge about tourism to local people. However, tourist industry, in fact, is partly related to seasonal advantages which depend upon weather and climate condition of a country.

Tourism cannot give an annual income for the whole year. There are peak season and off-peak season in tourist industry of Myanmar. Peak season or maximum number of tourist arrivals is found between October and March. Off-peak season or minimum number of tourist arrivals is found between April and September which is a monsoon period. In 2010, the lowest number of tourist arrivals was found in June and the maximum tourist arrival was observed in November (Table 2 and Fig. 2). Hotels, restaurants, souvenir shops and other tourism related businesses are more beneficial in tourist peak season than off-peak season.

In recent period, there is gradual increase in off-peak season tourist arrivals due to improved infrastructure such as transportation and communication facilities. If

infrastructure is developed and supported in tourist industry for the whole year, socio-economic condition of Nyaung U area will be more developed. Number of restaurants and food shops are growing due to increasing tourist arrivals and local visitors. There were only 5 food shops in 1990 and it increased to 40 shops in 2006 and reached to 134 shops in 2010. Restaurants and food shops are more beneficial in high tourist arrivals and local visitors. This development of food services also support the better income for foodstuffs, vegetables and other consumer goods sellers from village areas. Therefore, tourism development supports not only urban dwellers but also for rural villagers.

Table 2. Seasonal Tourist Arrivals of Bagan-Nyaung U (2001-2010)

No.	Month	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total	%
1	April	3,423	4,125	3,330	3,726	3,624	4,785	5,715	2,787	2,672	3,621	37,808	5.53
2	May	2,444	2,005	2,041	2,175	2,581	2,447	3,627	1,011	1,913	2,229	22,473	3.29
3	June	1,218	1,201	1,023	1,594	1,463	1,990	2,340	331	1,196	1,585	13,941	2.04
4	July	2,231	2,675	2,271	3,099	3,148	3,881	4,278	826	2,413	3,483	28,305	4.14
5	August	5,726	5,617	3,336	5,355	5,226	6,636	7,444	1,329	3,652	5,255	49,576	7.25
6	September	2,071	3,013	2,232	2,643	2,646	3,632	4,279	1,156	2,572	3,287	27,531	4.03
7	October	3,853	6,207	4,656	5,760	5,901	7,922	1,241	2,670	5,134	6,700	50,044	7.32
8	November	7,294	12,222	9,233	12,331	11,649	15,590	4,999	5,108	9,703	11,379	99,508	14.56
9	December	6,039	9,799	8,725	9,739	9,110	12,392	4,920	4,540	9,159	10,721	85,144	12.46
10	January	8,453	8,686	11,892	10,603	10,487	10,335	14,887	6,384	6,288	10,560	98,575	14.42
11	February	9,682	8,658	11,718	9,727	9,964	10,309	15,357	6,720	5,806	10,293	98,234	14.37
12	March	6,137	6,232	8,433	7,170	7,221	8,321	11,323	5,273	4,553	7,718	72,381	10.59
	Total	58,571	70,440	68,890	73,922	73,020	88,240	80,410	38,135	55,061	76,831	683,520	100.00

source: Ministry of Hotel and Tourism (Bagan)

Table 3. Tourism Related Economic Businesses of Downtown Area of Nyaung U

No	Wards	Tourism related economic businesses						
		Restaurants	Hotels	Stores	Souvenirs Shops	Lacquareware Shops	Internet	Air Ticket Services
1	No.1	7	0	7	0	0	0	0
2	No.2	13	2	5	1	0	0	0
3	No.3	18	11	12	0	0	2	2
4	No.4	22	11	20	5	0	4	4
5	No.5	51	10	3	29	23	4	3
6	No.6	1	1	3	0	0	0	0
7	No.7	8	4	1	3	2	2	0
8	Kyansittha	4	20	3	1	1	1	0
9	Anawyahta	3	15	2	0	2	0	0
10	Thiripyitsaya	7	1	3	0	5	0	0
11	Shwetwin	0	0	0	0	0	0	0
12	East Ywanaung	0	0	0	0	0	0	0
13	Ganga	0	1	5	0	0	0	0
	Total	134	76	64	39	33	13	9

Source: Township Administrative Office, Nyaung U

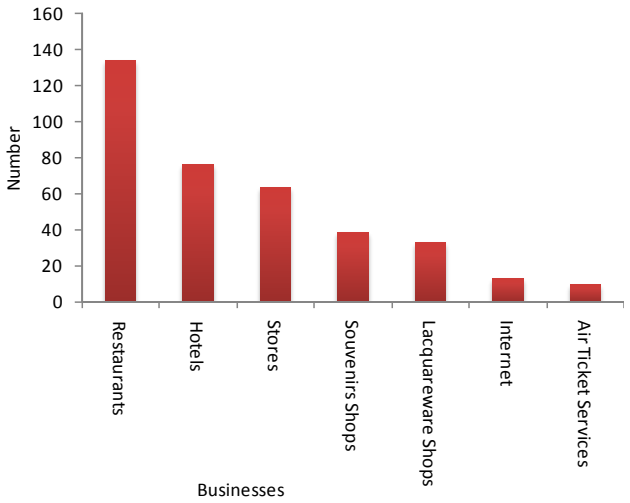

Fig. 3. Tourist Related Economic Business of Downtown Area of Nyaung U

Number of souvenir shops increased due to the growth of tourist arrivals and domestic visitors. The most favorites souvenirs sold in Bagan-Nyaung U area are lacquarewares, paintings and statues, local food products and souvenir shirts. Foreign visitors mostly buy lacquarewares, paintings and statues whereas local visitors buy local foods and souvenir shirts. Due to the support of tourism development, transportation and communication development, the quality of lacquareware products from Bagan area significantly increased. It is demanded for foreign exports to Italy, Germany and France. There are 65 lacquareware workshops in Nyaung U area. Businesses related to paintings and sculptures are also developed by the increasing demand from tourist industry.

Local food products industries are also developed due to the increasing demand of domestic visitors. Machines are increasing used instead of manual workers to produce local food such as “Poneyegyi or Bean Paste” which is a famous local food made by using beans. Increasing quality of package and food quality, Poneyegyi or Bean Paste

industry is significantly develop in Bagan-Nyaung U. Domestic visitors prefer t-shirts as souvenirs to give other people in their native areas. Therefore, this industry is also growing mainly due to domestic tourism. Design drawing for t-shirts and printing industry is also developed related to this t-shirt cottage industry. There are 185 souvenir shops in famous pagodas such as Arnandar, Shwezigon, Bupaya, Alodawpyi and Myazaydi pagodas. These shops also create job opportunities for local people. Therefore, tourism development can support the opportunities of job for local people in Bagan-Nyaung U area.

In 2010, there are 7 main businesses related to tourist industry in Bagan-Nyaung U. They are 134 restaurants, 76 hotels, 64 stores, 39 souvenirs shops, 33 lacquareware shops, 13 internet services and 9 air ticket services. These businesses are largely dependent on tourism. Majority of businesses are restaurants, hotels and stores. In fact, restaurants, hotels and air ticket services, hotels and air ticket services are directly related to tourist industry whereas stores, souvenir shops, lacquareare shops and internet services are indirectly related to tourism in Nyaung U. (Table 3 and Fig. 3)

Models Application in Tourism Development of Bagan-Nyaung U: Since tourism development is very important for socio-economic growth of Bagan-Nyaung U, it is necessary to study the role of tourism development in Bagan-Nyaung U by using some theoretical measures.

To apply the Butler's model of the hypothetical evolution of a tourist area to Bagan tourism, two variables such as the time factor and the number of tourists are plotted on X axis and Y axis respectively. The resultant two figures approximately coincide with the "development stages" as shown on Buler's Model. (Table 4 and Fig. 4)

Table 4. Tourist Arrivals of Bagan-Nyaung U (1991-2000)

No	Years	No of Tourists
1	1991	8680
2	1992	13110
3	1993	30490
4	1994	44838
5	1995	66923
6	1996	88057
7	1997	92691
8	1998	98608
9	1999	99604
10	2000	105961

Source: Ministry of Hotel and Tourism

Butler (1980) has developed a complex model of the hypothetical evolution of a tourist area. (Figures 3-5) Six stages are classified as exploration, involvement, development, consolidation, stagnation and rejuvenation or decline. No specified facilities for visitors exist in the first stage; those in the involvement stage are provided primarily by locals. In the development stage local involvement and control decline rapidly.

Major franchises and chains in the tourist industry will be represented by the consolidation stage. Again local involvement increases in the decline stage "as local employees are able to purchase facilities at significantly lower prices as the market declines".

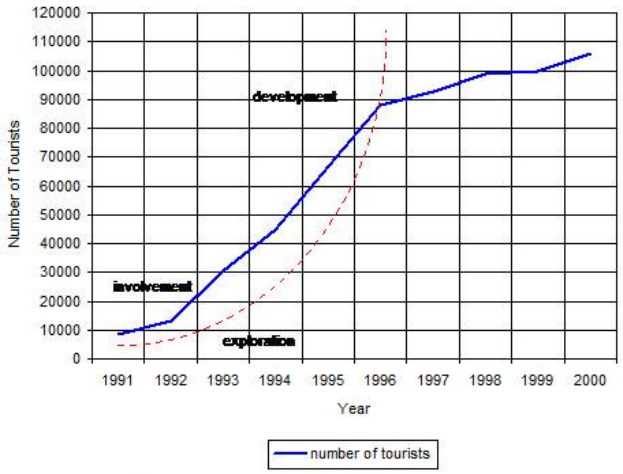

Fig. 4. Analysis of tourism development by bulter's model

The present condition of tourism in Bagan-Nyaung U, according to Butler'model is in the early part of 'development stages'. Tourism in Bagan-Nyaung U experienced the 'exploration stage' and 'involvement stage'. The applied model indicates two significant periods in the development of tourism in Bagan-Nyaung U. The two resultant patterns were found from 1991 to 2000 and from 2001 to 2010. Both of these periods experienced two stages, namely exploration and involvement.

Various stages recognized in the Butler's model significantly coincide with the actual condition of tourism in Bagan-Nyaung U. It is now in the early part of 'development stage' and it can be postulated that there would be a perfect 'development stage' in the near future as six sequential development phases depicted on the Butler's model. (Table 5 and Fig. 5)

Table 5. Tourist Arrivals of Bagan-Nyaung U

No	Years	No of Tourists
1	2001	58571
2	2002	70440
3	2003	68890
4	2004	73922
5	2005	73020
6	2006	88240
7	2007	80410
8	2008	38135
9	2009	55061
10	2010	76831

Although there were several fluctuation in tourist arrival trend, there was a tendency towards a new development after 2010 when a new political and economic policies of Myanmar was significantly introduced. This new trend of tourism development will also support the socio-economic growth of Bagan-Nyaung U.

Impact of Tourist Industry on Socio-economic Development: Major impact of tourist industry on socio-economic growth of Bagan-Nyaung U is significantly observed in some economic activities such as; (a) Handicraft industry, (b) Food and beverages shops, and (c) Hotels and accommodation services

In order to study the impact of tourism on these businesses, shops and business were selected as samples for questionnaire distribution and interview survey.

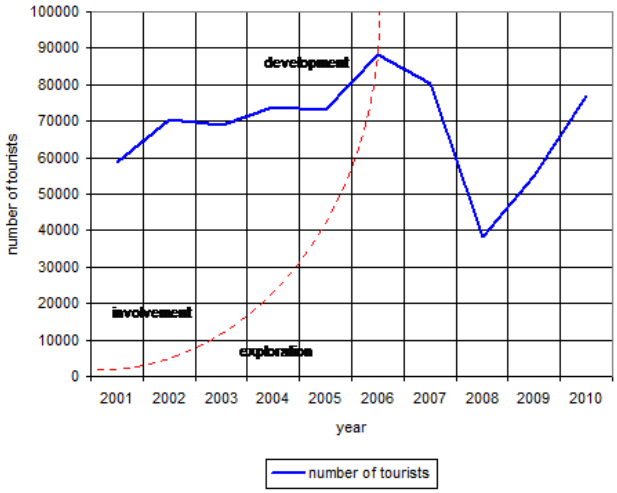

Fig. 4. Analysis of Tourism Development by Butler's Model (2001-2010)

There are 12 respondents for handicraft industry, 4 respondents from food and beverage shops and 7 respondents from hotels and accommodation services. This study only focused on qualitative assessment on the impact of tourist industry in Bagan-Nyaung U.

Handicraft Industry: Handicraft is a main cottage industry which is supported by tourism in Nyuang U District. Handicraft is traditionally done by villagers from Bagan and Nyaung U area. The main product is a lacquarewares made of bamboo and natural dyes produced from plants and some kinds of rocks and soils.

Respondents answered that their lacquareware industry is closely related to tourist industry and when the more visitors come the more lacquareware products are sold. Therefore, they pointed out that the economic growth of Bagan-Nyaung U area is significantly influenced by tourist industry. By the connection of tourist, some lacquareware products are exported to foreign countries through Singapore. Although local visitors buy lacquareware products, the demand is less than that of foreign visitors from Europe, Americas and the rest of Asia.

Food and Beverages Shops and Restaurants: Another business sectors related to tourist industry in Bagan-Nyaung U is food and beverages shops and restaurants. Some owners of food and beverage shops and restaurants were requested to reply the questionnaires.

There are two types of food shops such as Myanmar traditional food and Chinese style food. Both types are preferable for tourists and local visitors. In recent years, with the development of tourist industry, some restaurants also tried to perform purpet shows during the night time. It also attracts to tourists. Therefore, traditional purpet show is gradually developed again due to the growth of tourist industry in Bagan-Nyaung U area.

The respondents answered about their income from food and beverages shops by averaging 1 lakh kyats to 5 lakh kyats. About 75 percent of the shop owners earned 6 lakh to 10 lakh kyats from food and beverages.

Hotels, Motels, Inns and Guest Houses: The most significant development is found in the growth of hotels, motels, inns and guest houses (Fig. 6). This business sector is directly related to tourist industry. The basic requirement for international tourists is hotels and motels for their accommodation and stay. Most of the respondents, who are managing hotels and guest houses, are age group between 20 and 40 years (72% of total respondents).

Fig. 6. Tourist Industry and its related Economic Activities in Bagan-Nyaung U Area

Most of the visitors stayed in hotels, motels and guest houses are foreigners. Therefore, hotels, motels and guest houses are mainly dependent on tourist arrivals. December to February is the peak season for tourist arrivals. Local visitors usually come to Bagan area between April and October. At that time most of the hotels, motels and guest

houses are crowded. However, big hotels and high standard hotels and guest houses are generally preferred by tourists from foreign countries. Local visitors preferred low price guest houses.

Conclusion: This study pointed out that hotels and high price guest houses are mainly relied on tourism and tourism related activities. Until 2010, tourism is seasonal business. Most of the hotels are vacant in the off-peak season during June and October, monsoon period. It is necessary to promote tourist industry to be a year-round business. Moreover, the export of home-made commodities are also recommended and made come important contacts by tourism. Handicraft is supported by tourism in Bagan-Nyaung U area which is necessary to maintain the present condition.

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J. Agrofor. Environ. 11 (1 & 2): 103-106, 2017 ISSN 1995-6983

Farm size categories and agricultural implements used for farming: a case study in Baghaichari Mukh village, Chittagong hill tracts, Bangladesh

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Abstract: The paper aims to reportthe types, sources and functions of the existing agricultural implements of indigenous Chakma people, who live in the Chittagong Hill Tracts of southeast Bangladesh. The major farming system in Chittagong Hill Tracts is still traditional. Subsistence farming of small farmers is most prevalent where farming is carried out in a traditional way using with hand-made agricultural implements from wood and bamboo. Also a great deal of human labor and animal-draught power is required for land preparation, sowing, transplanting, harvesting and processing. Recently, modern implements (e.g. power tiller) as well as locally existing agricultural implements began to be used for rice cropping system in the village. However, farmers' practices and management are still kept as traditional ways that they are taught from their ancestors in the village. Some farmers prefer using draft power more than the power tillers, because they thought drought power can till the land deeper. According to the interview with a few farmers, deep tillage can control weed seeds which enables high yield, whereas the tillage with power tiller is not good for the yield. Some farmers said that the power tiller is very useful in the rainy season for preparing puddle soil. Farmer opines that power tiller is required less time in order to tilt the land though some farmers prefer modern implements.
Key words: Chittagong Hill Tracts, farm size categories, existing agricultural implements and modern implements.

Introduction

Chittagong Hill Tracts (CHT), cover an area of 13,295 km^2 is situated southern part of Bangladesh, bordering the Rakhine and Chin Sates of Myanmar and Tripura and Mizoram Sates in India (Background of Chittagong Hill Tracts, 2002). It is the land to nearby twelve indigenous groups, who do not exactly share a common language among themselves, but who are so far part from majority Bengali population in terms of indigenous background, religious and socio-cultural practices. These indigenous peoples are called *jhumma* that include the people who cultivate *jhum* (swidden cultivation). *Jhum chas* (swidden cultivation) is practiced by the indigenous communities of the Chittagong Hill Tracts regions since time immemorial.

The major farming system in Chittagong Hill Tracts is still traditional. Subsistence farming of small holder farmers is most prevalent where farming is carried out in a traditional way using with old and indigenous farming implements and little inputs. This involves a great deal of human labor and animal-draught power for land preparation, sowing, transplanting, harvesting and processing. The use of animal-drawn implements of today is a crucial in realizing the current socio-economic condition of Chittagong Hill Tracts. Improvement of agricultural implements is a prerequisite and important for any improvement of agriculture as a whole. However, research on locally existing agricultural technologies in Japanese ZAICHI NO GUUTSU (Ando, 2011) has been so far considered a neglect subject and detail and comprehensive study is still lacking in Chittagong Hill Tracts. Besides, there have been few research efforts to encourage the use of appropriate farm implements which has a great potential increase the national production. Therefore, the study aims to identify the types, sources and functions of the existing agricultural implements in the study area.

Materials and Methods

This study was carried out in Baghaichari mukh village Under 51 No Dighinala Union of Dighinala Upazila of Khagrachari district. The village is located about 30 km away from the district headquarters. The field surveys were carried out in 2005.The village stretches 500 m from south to north and 3 km from east to west. The Mayani River flows through the western part of the village. One concrete road runs from north to south. The reserved forest is located in eastern part of the village. There were 247 households in the study village and were interviewed by questionnaire. In addition, interviews using a semi-structured questionnaire and field observations were also conducted. Three distinct cropping seasons existed in this area. The summer season was in March and April and it is characterized by high temperatures and humidity with occasional thunderstorms and cyclones. The rainy season started in May and ended in October, while winter started in November and ended in February (Soil Resource Development Institute, 2002). Based on long-term records (1961-1990) obtain from the Rangamati Weather Station, rains began in February, gradually increased until July, and then decreased. Ninety percent of the rainfalls occurred during the rainy season from May to October. The highest (627 mm) and lowest (4 mm) amounts of rainfall occurred in the months of July and January, respectively. Maximum 33^0C and minimum 20^0C temperatures were recorded in April and January (BBS, 2001).

Results and Discussion

Farming practices and agricultural implements uses in the study village: Farming practices in Baghaichhari mukh village include cultivation techniques, and farming implements.

Seed germination: At first, about 1 Ari (1 Ari= 10kg) of seeds are placed in a bag (locally call such as *bosta, karang, leye, or maralla*) and soaked in water for one day. Then the seeds are placed in another bag, covered with banana or teak leaves for 10-12 hours and kept in the house. The seeds are then soaked in water for a while, covered with any green leaves (again, teak or banana), until the seeds are germinated. Within 22-24 hours the seeds begin sprouting.

Preparation of seed bed: The seed bed is prepared in the different land types, but mostly it was practiced in the homestead areas and near the rice fields (Fig. 1a).

Ploughing: This is usually done by with a plough and a team of two bullocks (Fig. 1b). Most farmers prefer tillage with a *naol* (a traditional plough) for its deep tillage, but

some preferred a power tiller. Most still preferred the *naol* for its deep tillage. According to the farmers, deep tillage controlled weed seeds and yield was increased, whereas the tillage with power tiller was not good for the yield.

a b

Fig. 1. (a) Seedbed, (b) Ploughing the paddy plot by using bullock

The farmers also revealed that the power tiller is very useful in the rainy season for preparing puddle soil for transplanting aman. Though most farmers still preferred the traditional plow, the fact that power tilling required less time impressed many enough to use it. In the study area, farmers plowed 3 to 4 times with the traditional plow, or 2 times by power tiller (although they still used the traditional plow to plow once for the final land preparation). The plowing time is very early in the morning (from 5 to 10 a.m.). This is completely different from other plain areas. If a farmer rented a pair of bullocks, he would pay 50 Taka for 5-6 hours each day. A farmer using a power tiller would pay 200 Taka to plow 40 decimal of land.

Harrow: The farmers level the paddy field with a leveler (locally called *shapta*), which is pulled by two bullocks while the farmers sat on the level (Fig. 2a).

After one plowing is completed; one leveling is needed for pressing the soil tightly. Three repetitions of plowing and leveling are necessary for good land preparation. This implement is used for leveling of cultivated land and also to break clods. It is made of three pieces of split bamboos or wood.

Transplanting: Transplantation is done manually (Fig. 2b). Regarding irrigation facilities, farmers make a small reservoir to collect water in a small piece of land. Villagers usually followed a local custom of having fixed days for transplanting and harvesting. There is a proverb which says, '*shom shokkure lagai dhan, bode breshode ghorat an'*. This means that one should plant rice on Monday and Friday, and harvest on Wednesday and Thursday.

a b

Fig. 2. (a) Farmer leveling the paddy plot by the ladder, (b) Transplanting of rice seedling

Weeding: Weeding is usually carried out manually 15-20 days after transplanting (Fig. 3). Family labor is mainly used but sometimes-hired labor is needed. The fertilizers commonly used are Urea, T.S.P (Triple supper phosphate) and M.P. (Murate of potash). However, the amount of fertilizer application is limited to a rate of about 10kg in each plot because of its high cost.

Fig. 3. Weeding done by male and female

Pesticide: The commercial names of pesticides widely used in the village are Ripcord, Furadan and Basudin. Farmer locally makes implement for pesticide sprayer (Fig. 4).

Fig. 4. Locally made implement for pesticide sprayer

Farmers also used an indigenous method especially for rice bugs. When a side of a plot became dry while the other sides of the plot remained wet, the *chunapada rug* (meaning to look like calcium chloride) attacked the plot and the rice leaves become whitish and the plants became weak. Farmers put some branches of *kuruk* around the affected plot (Fig. 5). Farmers believed that the rice bugs cannot be eradicated by pesticides or insecticides and that *'kuruk'* (a wild shrub) branches can make the rice bug run away from the field. When rice hispa attacks at the milking stage, farmers place some shrimp paste or fish paste wrapper on the top of sticks. The rice hispa comes to the stick instead of attacking the rice. In the mean time, filling of paddy grain are completed and infestation of rice hispa can be avoided.

Fig. 5. (a) To control rice bugs, farmers placed 'Kuruk' tree branches into the paddy plot, (b) Insect control using these 'Kuruk' tree branches

Harvesting and seed production: Before harvesting the crop, the farmers pray to God to give them more rice. This is locally called *To Do Fung*. Farmers harvested the rice by hand using sickles, and the rice plants would generally be cut around the middle portion (Fig. 6a). The bottom part is left to decompose to fertilize the next crop. Another advantage of cutting at the middle is that they can be carried easily by making bundles (Fig. 6b and 6c).

a b c

Fig. 6. (a) Paddy harvesting by using sickle (b & c) Farmers carry bundle of paddy.

The bundles are carried to the homestead and arranged in a circle on a threshing floor to be trampled by bullocks. The bullocks are driven side by side over the circle of rice in a counter clockwise direction (Fig. 7a). After several rounds, the bundles are piled up again and trampled in the same way. 3-4 cows are needed to thresh the large amount of rice. In the case of small amounts of rice, farmers thresh them by treading over them. It takes at least 2-3 days to thresh the rice from a 40 dec. farm. Working hours are at least 3 hour per day per day. Then the straw is removed and the rice grains were collected. They are cleaned by winnowingor *kula* (Fig. 7b), and sun dried for 2-3 days. After drying, the seeds are stored either in *gola* or *chidira* (a storage house made of bamboo). Seeds were carried in a small basket made of woven bamboo (Fig. 7c).

a b c

Fig. 7. (a) Farmers trampled paddies by bullock, (b) To removing the unfilled grains and dust by using (*Kula*), and (c) Bamboo made basket

Sickle: Sickle is locally called 'charey'. It is a man and women operated implement for paddy harvesting. Materials of construction are locally available and made by locally blacksmith.

***Jhum* Cultivation Implements:** *Jhum* was a type of cultivation practice particularly followed in the Chittagong Hill Tracts. Instead of cultivation the entire region, holes at different distance were dug in the soil and seed placed therein. The following implements we generally used in Chittagong Hill Tracts.

Tagol: It was used for cleaning of the *jhum* cultivation area by cutting shrubs and herbs and twig of trees (Fig. 8). It was also used for digging holes for sowing seeds. The length of the blade was 25 cm and handle is 25 cm. It is made by the village blacksmith and costs Tk 80 at the market. It was perhaps the most extensively used implement in *jhum* cultivation from start to the end.

Fig. 8. *Tagol*

Kurum: Seeds were carried in small basket (Kurum) made of woven bamboo (*Agocha* bash). It was 25cm long and 20cm in diameters at the mouth. It was carried at the back of the user and hold tight at the komor with a rope fitted with the kurum (Fig. 9.). It was made by the village artisans and costs Tk 50 at the market.

Fig. 9. *Kurum*

Possession of number of agricultural implements classified by farm size categories in the study village

It is found that the number of agricultural implements are being utilized by the farm size categories hass been varied. Table 1 shows that most of the agricultural implements are possessed by small farmers including the plough 62%, yoke 60%, ladder 61%, spade 65%, and sickle 91% but they do not possess modern implements. Among the modern implements like power tiller most of them are possessed by large farmers (66%). It is also found that landless farmers, which are very few in number as they are usually involved in off farm activities, have only a spade and sickle. But medium farmers possess all types of implements. More farmers from medium farm size categories possessed the various items of agricultural implements compared with other farm size categories. There are three power tillers in the village almost all of which are possessed by the medium and large farm size households. The owners rent their power tiller to other farmers in the peak season of land preparation time. From the above result it is also being shown that the number of farming implements has a relation with land tenure systems. The small and medium farmers are involved in rent-in system and they have to have more implements on the contrary the large farmers are involved the rent-out system and comparatively are less possessed. According to the interviewed with farmers that deep tillage controls

weed seeds and yield is increased, whereas the tillage with power tiller is not good for the yield. The farmers are also revealed that the power tiller is very useful in the rainy season for preparing puddle soil for Transplanting Aman seasons. Some farmers are opined that power tiller required less time in order to tilt the land. Existing agricultural implements are constituted important assets of the farmers in the study area.

Table 1. Possession of number of agricultural implements classified by farm size categories in the study village

Farm size categories in ha	Number of Households	Number of implements						
		Different farming implements					Modern implements	
		Plough	Yoke	Ladder	Spade	Sickle	Tube well	Power Tiller
Land less	12 (4.9)	0 (0.0)	0 (0.0)	0 (0.0)	5 (1.8)	9 (0.4)	0 (0.0)	0 (0.0)
Small <1.0	163 (65.9)	139 (62.0)	130 (60.0)	133 (61.0)	178 (65.9)	2240 (91.0)	2 (33.3)	0 (0.0)
Medium 1.0-3.0	61 (24.7)	64 (28.6)	61 (29.0)	62 (29.0)	72 (26.7)	176 (7.1)	2 (33.3)	1 (33.3)
Large >3.0	11 (4.5)	21 (9.4)	23 (11.0)	21 (10.0)	20 (7.4)	37 (1.5)	2 (33.3)	2 (66.7)
Total	247	224	214	216	275	2462	6	3

Source: Survey in 2005, Note: Figures in parentheses indicate percentages

Existing agricultural implements own made & purchased by farmers of different farm size categories in the study village

In this study, the most important existing agricultural implements are found such as plough, ladder, yoke, sickle, spade, tube well and power tiller. Some implements are mainly own made by farmers and some are bought from local markets. BARC (1982) also listed such impliments which were indentified in this stusdy. Most implements are imported from outside village or India is mainly brought throughout unofficial lines, it is meant by farmers themselves under their own expenses and management. The modern agriculture implements such as power tiller and water pumps are introduced into the village; power tillers are introduced 5-6 years ago by the large farmer. However, at that time, some modern implements already are existed such as small water pumps. Recently, both modern and local implements are used in the village. However, from viewpoints of the farmers' practices and management are still kept as traditional ways that they are taught from their ancestors in the village. It is cleared that the existing agricultural implements have developed based on the physical conditions of a locality such as land use and soil type, particularly soil structure, depth of plough pan, nature of crop grown and also the socio-economic condition of the farmers. These existing agricultural implements have direct impact on the existing farming systems of the study village.

Conclusion

Recently, both modern and local farming implements are used in the village. However, from viewpoints of the farmers' practices and management are still kept as traditional ways that they are taught from their ancestors in the village. Some farmers are preferred using draft power more than the power tillers because, they thought that it can be tilt the land deeper. According to the interview with farmers that deep tillage controls weed seeds and yield is increased, whereas the tillage with power tiller is not good for the yield. The farmers are also revealed that the power tiller is very useful in the rainy season for preparing puddle soil for Transplanting Aman seasons. Some farmers are opined that power tiller is required less time in order to tilt the land. It is cleared that the existing agriculture implements are developed based on the physical conditions of a locality such as land and soil type, particularly soil structure, depth of plough pan, nature of crop grown and also the socio-economic condition of the farmers.

Acknowledgement: The data presented in this report was originally gathered as part of the first author research for PhD. dissertation at the Graduate School of Asian and African Area Studies, Kyoto University. Successive field trips for the research were supported by the 21st Century COE Program "Aiming for COE of Integrated Area Studies." Run by the Graduate School of Asian and African Area Studies. The first author wishes to express his gratitude to the institution. The authors would like to extend sincere thanks to Dr. Haruhisa Asada who provided us valuable comments for completing this report.

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J. Agrofor. Environ. 11 (1 & 2): 107-113, 2017 ISSN 1995-6983

A traditional farmers' practice of black gram (Mat-pe) (*Vigna mungo*) cultivation in Maubin township, Ayeyarwady region, Myanmar

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Abstract: The largest black gram sown areas are concentrated in Ayeyarwady Region of which the large productive areas are Danuphyu, Maubin and Nyaungtone Townships. Black gram is widely grown as a second crop after monsoon rice in the post monsoon season with residual soil moisture. The unique feature of black gram cultivation in these regions is that there exist three traditional agronomic practices, locally known as "Htun-pe, Ye-lite-pe and Khoke-phone-pe". Farmers follow one of these methods depending on the soil moisture condition of their fields and sowing time. When they have sufficient time for proper land preparation with suitable soil moisture they practice "Htun-pe". In the reverse condition, farmers follow the zero tillage systems called "Ye-lite-pe" and "Khoke-phone-pe". The latter two practices have been widely adopted by farmers in Ayeyarwady Region since 1990s. Field surveys were carried out in Maubin Township during 2005-2006 to document the information on an appropriate location-specific cultivation technology of black gram. The estimated enterprise budget indicates that Khoke-phone-pe gave the greatest benefit-cost ratio of 4.3, while Ye-lite-pe and Htun-pe contributed benefit-cost ratio of 3.7 and 3.6, respectively. It clearly shows that "Khoke-phone-pe and Ye-lite-pe" can give as much net return as "Htun-pe". Many farmers prefer "Khoke-phone-pe and Ye-lite-pe" because of its low input and low management requirement.
Key words: Black gram, Khoke-phone, relay cropping, residual soil moisture.

Introduction

A number of agricultural management practices, such as cropping patterns and sowing practices have long existed traditionally in different agro-ecological regions in Myanmar. Farmers have developed them over time with long time experiences and their needs. At present, Myanmar has been standing as a lead country of pulses production among ASEAN countries. Since 1990, the country's pulses production and export have been increasing due to the drastic rise in price of pulses, as a consequence of the liberalization of government trade policy, and introduction of new improved varieties (Myanmar Agricultural Statistics, 2001). In 2005-2006, pulses production was the second highest after rice of all the national agricultural crops production (Fig. 1 and Fig. 2). In recent years, black gram has been the biggest export crop among the pulses followed by pigeon pea and mung bean (Myanma Agriculture in Brief, 2006). The largest black gram sown areas are concentrated in Ayeyarwady Region (46 %) and Bago Region (40 % of the total) (Table 1 and Fig. 3). The most productive areas in Ayeyarwady Region are, in order of importance, Danuphyu, Maubin and Nyaungtone Townships. In these areas black gram is widely grown as a second crop in post monsoon season with the residual soil moisture after monsoon rice. The unique feature of black gram cultivation in these areas is that there are three traditional sowing practices, namely "Htun-pe, Ye-lite-pe and Khoke-phone-pe". Farmers follow one of these practices depending on the soil moisture condition and sowing time. When they have sufficient time for proper land preparation with suitable soil moisture, they practice "Htun-pe". In the reverse condition, i.e. when the land available for black gram sowing is late, farmers follow zero tillage method/ system called "Ye-lite-pe" and "Khoke-phone-pe". Information on traditional farmers' technologies, that are optimum crop management practices in a particular agro-ecological situation, is of great importance in order to increase crop productivity. These technologies or practices largely depend on agro-ecological suitability, such as rainfall, soil type, labor availability, food requirement, marketability and etc. Only a very few research works of such nature have been done Myanmar, and therefore this survey research was carried out with the objectives: (i) to observe the existing technology of black gram cultivation in lower Myanmar and its trends of production, (ii) to document the information on the appropriate location-specific cultivation technology of black gram and to disseminate it in other areas, and (iii) to identify the constraints and the potential areas for expansion of black gram production in rice based cropping system

The information of this study will be a base line for the future research efforts leading to the improved pulses production in Myanmar.

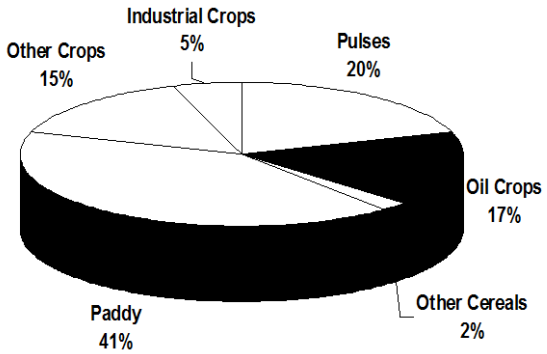

Fig.1. Crop Production of Myanmar in 2005-2006
Source: Myanmar Agriculture in Brief, 2006

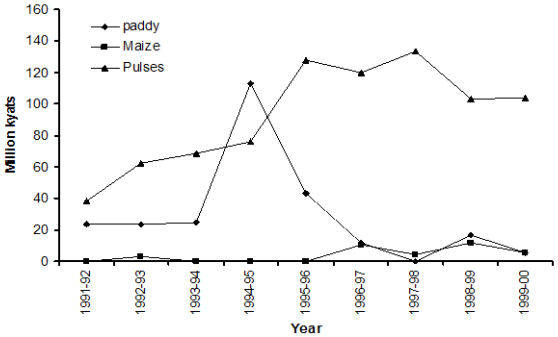

Fig. 2. Export of Main Agricultural Products from Myanmar
Source: Settlement and Land Records Department, 2001

Table 1. Black gram production in Myanmar, 2005-06

State/Region	Monsoon (Acres)	Post monsoon (Acres)	Yield/ acre	Total yield (basket)
Kachin		149	9.8	1,453
Kayar				-
Kayin		79	10.6	840
Chin		75	12.5	938
Sagaing	1838	114,719	15.7	1,827,316
Tanintharyi		107	5.8	624
Bago		434,921	15.6	6,797,815
Bago(West)		373,177	15.2	5,683,486
Magwe		19,601	14.7	287,939
Mandalay		49,914	13.4	666,352
Mon		8,338	13.5	112,646
Yakhine		43,896	9.9	433,692
Yangon		41,542	13.2	547,108
Shan(south)		26	8.8	228
Shan(north)		220	12.1	2,651
Shan(east)				-
Ayeyarwady		925,851	16.1	14,906,201
National Total	1838	2,012,615	15.5	31,235,785

Source: Food Legumes Section, Myanmar Agriculture Service, Yangon

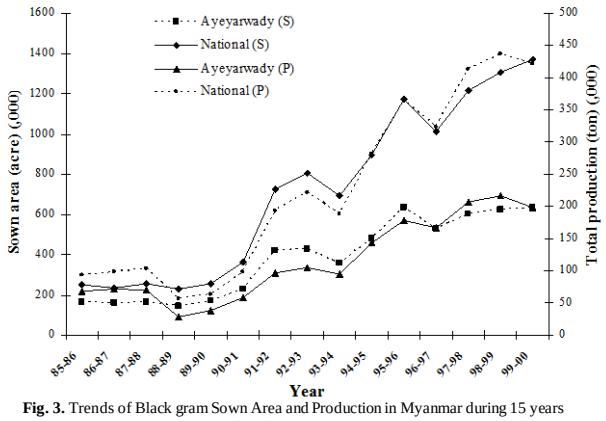

Fig. 3. Trends of Black gram Sown Area and Production in Myanmar during 15 years
Source: Myanmar Agricultural Statistics, 2003 (S= Sown Area; P= Production)

Materials and Methods

Field surveys were carried out in Maubin Township during the black gram growing season during 2005-2006. Ten farmers were randomly selected from each three villages, namely Nga-gyi-ga-yet, Kyone-soke and Alan-gyi, of Maubin Township. They were interviewed with structured questionnaires to study the farmer level production systems of black gram and demographic characteristics of farming communities. The data collected were demographic data, family size, farm size, farming experience and technical data concerning with black gram production technology. The secondary data were obtained from Myanma Agriculture Service (currently, Department of Agriculture), Maubin District and Food Legumes Section, Ministry of Agriculture and Irrigation (Currently, Ministry of Agriculture, Livestock and Irrigation).

Results and Discussion

Mono cropping of rain-fed rice was predominant in Lower Myanmar until 1952-53, and the rice varieties used were traditional late-maturing varieties such as Sa-pa-net, Bo-daw-gyi, Taung-pan, etc. with long stems and low yields. In a very few places where residual soil moisture was available for second crop, farmers cultivated Pe-nauk (a local variety of mungbean) and groundnut for their subsistence during post-monsoon season. After about 1955, black gram varieties namely, Boke-hmwe, Hin-tha-da mat-pe, which had a spread type of growth habit, were introduced into these areas as the second crop after rice. Only when there was enough time after rice harvest for optimum land preparation for the next crop, black gram was grown after normal ploughing and harrowing. This practice was called "Htun-pe" ("Htun means harrow and Pe means pulse") meaning "pulse growing after land preparation with harrow".

A common problem for black gram growing was a difficulty of a proper land preparation with a plough and a harrow for black gram after the rice harvest. The soil was too hard or too wet to plough depending on the amount of rainfall and its distribution during the late monsoon season, as well as the rice harvest time. If the farmers do the normal land preparation which takes 1-2 weeks, it will make black gram sowing late, and there will be insufficient soil moisture to facilitate the later growth of the crop, resulting in low yield. Therefore, some farmers did not prepare their lands and modified their sowing practices to coincide the sowing time with the appropriate soil moisture condition for good crop establishment. Black gram seeds were broadcast before or after the rice harvest with zero tillage. Before the rice harvest, rice stems were pressed with bamboo poles to become a slanting position for easier harvest operation. Rice was harvested manually with sickles and long rice stubbles were maintained in the field after the harvest. Black gram plants grew among the stubbles, twined them, flowered and gave a certain yield. In general, black gram seeds were broadcast on saturated soils about 3-10 days before the rice harvest, as a relay crop (by the end of Oct. to mid-Nov).

By this method, sowing time could be advanced about 2 weeks so that drought stress which generally occurred during the later stages of black gram could be avoided to a certain extent. This practice was developed in about 1958 and it was known as "Ye-lite-pe" ("Ye means water, lite means accompany"), meaning "pulse growing together with soil water". Some farmers, after the broadcasting of black gram seeds, pressed the rice stubbles again by using "Jode" drawn by draught cattle. This method was called "Joke-se" and farmers believed that it could ensure the seeds to reach or touch the soil surface. Farmers assumed that Ye-lite-pe and Joke-se was almost the same practice

because most Ye-lite-pe farmers did Joke-se practice. The sowing methods of Ye-lite-pe or Joke-se facilitated timely sowing; significantly reduced the risk of crop failure caused by drought stress and substantially reduced the expense on land preparation. This traditional sowing method of black gram was commonly practiced on the river banks after the flood water had receded in lower Myanmar (Plate 1).

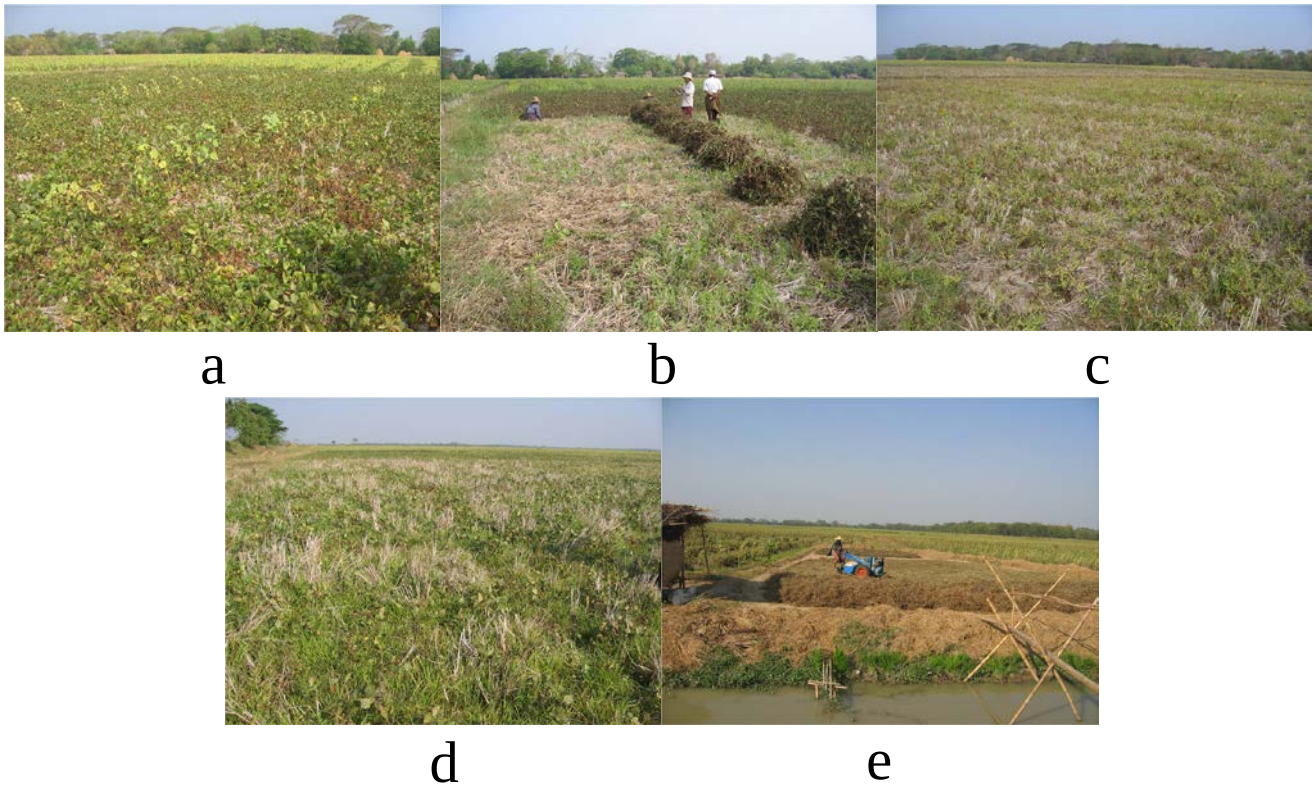

Plate 1. Black gram harvest in Nga-gyi-ga-yet Village Tract, Maubin Township (a) Khoke-phone method (black gram and sunflower before harvest), (b) Khoke-phone method (black gram harvest time- rice residues were clearly seen), (c) Khoke-phone method (black gram was harvested) (d) Ye Lite method (black gram was harvested), (e) Threshing of black gram

In late 1960s, high yielding rice varieties of short or medium duration with short stems were introduced into Myanmar. The first "Whole Township Rice Production Program" was initiated in Taikekyi Township, Lower Myanmar in 1977-78, and then these varieties were widely spread in Lower Myanmar (Rice in Myanmar, 2004). In 1980s, new improved varieties of black gram, such as Pa-le-net (P 11-30) and Ye-zin 2 (P 45-1) were distributed from the Department of Agriculture Research, and grown in Lower Myanmar. These new improved varieties have the characteristics of shorter duration compared with traditional varieties, short stems and the erect or semi-erect type of growth habit. When the seeds were sown among rice stubbles, as the farmers formerly did, the plants did not twine the rice stubbles. Moreover, they could not grow well because of poor light penetration due to the shade of the rice stubbles. In addition, farmers found difficulty to harvest the black gram plants among the rice stubbles with sickles. To solve the problem, some farmers cut the stubbles with long knives about 3-7 days after the rice harvest and left the straw residues among the black gram young seedlings. This practice was known as "Khoke-phone-pe" ("Koke means cut, phone means cover") meaning "cutting the stubble and covering the soil surface". Farmers gradually noticed that this practice gave a better black gram yield because of more moisture conservation and weed suppression due to mulching effect of rice straw. The Khoke-phone-pe technology was said to be developed by farmers of the village tracts of Tha-phu, Nan-chaung, Ye-le and Ye-kyi in Da-nu-phyu Township. After that, it was disseminated to the village tracts of Ka-nyin-kauk-kyi, Ta-zin-ye-kyaw, Kyone-yit in Nyaung-tone Township and then to Maubin Township. It became popular and widely followed by farmers in the whole Ayeyarwady Region, Lower Myanmar since 1990s.

Among these three agronomic practices, Htun-pe generally gives the highest yields. The choice of these practices firstly depends on the topography of land. The short or medium duration of high yielding rice varieties (with short and study stem) are usually grown in high land and areas of intermediate land level. These lands are not flooded or water recedes early, and rice is harvested early (Sept-Oct). Therefore, there is sufficient time for land preparation after the rice harvest, "Htun-pe" is practiced in these areas. Long-duration local rice varieties with long stems are grown in low – level lands and harvested late (Nov. – Dec.). In these areas, zero tillage method of "Ye-lite-pe" or "Khoke-phone-pe" is practiced because there will be no adequate residual soil moisture if the normal land preparation is done after rice harvest. Nowadays, because of its low input and convenience of cultivation practice farmers also practice "Ye-lite-pe" or "Khoke-phone-pe" in the areas of high and intermediate land level.

Secondly, rainfall and its distribution pattern determine the farmers' sowing practices. If early monsoon comes, rice is grown early and harvested early so that farmers have enough time for land preparation of black gram, and "Htun-pe" is practiced. In the reverse condition "Ye-lite-pe" or "Khoke-phone-pe" is taken place. Moreover, with the late monsoon withdrawal and the land is still wet, there will be late sowing of black gram if the farmers wait for the proper land condition for ploughing. Therefore, for the timely sowing of black gram, "Ye-lite-pe" and "Khoke-phone-pe" must be practiced. The annual rainfall and its distribution in Maupin Township for ten consecutive years (1996-2005) were described in Table 2.

Table 2. Rainfall (inches) in Maubin Township for ten consecutive years (1996 - 2005)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1996		3.54		2.65	9.97	18.4	12.34	17.41	15.16	5.5	4.06		89.03
1997			3.58			10.82	27.89	19.84	19.38	4.25	1.42		87.18
1998					12.3	19.23	12.7	11.61	9.52	5.85	0.9		72.15
1999			1.18	5.85	0.87	12.24	16.61	23.1	11.87	8.61	2.22		82.55
2000			0.07	3.72	7.92	18.42	12.68	13.44	16.49	3.51	0.08		76.33
2001			2.13		18.2	18.78	28.67	24.62	10.98	10.69	2.77		116.86
2002				0.31	14.6	19.25	15.02	22.26	17.8	6.85	4.79	0.57	101.42
2003			0.16	0.39	13.1	20.33	10.36	17.4	13.48	3.23	0.39		78.85
2004				0.51	18.1	21.73	18.63	31.41	9.73	3.43			103.5
2005				2.17	6.85	14.62	25.25	15.8	12.03	3.88	1.74		82.34
10-year average			1.42	2.23	11.32	17.38	18.02	19.69	13.64	5.58	2.04	0.57	89.02

Source: Department of Meteorology, Maubin Town

Thirdly, the moisture condition of the rice fields influences the farmers' practice. Dry- up top soil is a major determinant to crop establishment when black gram seeds are sown with residual moisture. Farmers, with their intelligence and longtime experience, decide which practice they have to follow depending on the following three conditions of the soil moisture of the field after the rice harvest.

(i) "Kho-nin-khan or Byaine-nin-khan" means a bird (a pigeon or egret) can easily walk on the soil surface. There is best moisture condition for black gram seeds to germinate and seedling emergence, and either "Ye-lite –pe" or "Khoke-phone-pe" is practiced.

(ii) "Lu-nin-Khan" means a man can easily walk on the soil surface. Although the moisture is less than the No.1 condition, the soil is good for "Ye-lite –pe" or "Khoke-phone-pe".

(iii) "Nwar-nin-khan" means a cow can easily walk on the soil surface. The moisture condition is less than the above mentioned and "Htun-pe" should be done due to its good moisture condition for tillage.

Table 3 shows the trend of black gram acreage in Maubin Township during ten consecutive years (from 1996 to 2006). It indicates that, black gram sown areas in 2005-06 were two times higher than those in 1996-97 (from 35,788 acres in 1996-97 to 83,789 acres in 2005-06). The percentage of double cropping of black gram after rice increased from 30 % in 1996-97 to 60 % in 2005-06. Among the monsoon rice growing areas in lower Myanmar, there are three types of rice eco-systems depending on the water condition of rice fields– (1) Ye-taw-moe-taw, a good management of water level (2) Ye-kyi-kwin, a plot often flooded with heavy rains, and (3) Ye-net-kwin, a plot mostly flooded for the rice varieties of deep-water-rice.

The black gram acreage under Ye-taw-moe-taw and Ye-kyi-kwin are static while Ye-net-kwin acreage increased from 26,932 acres in 1996-97 to 47,839 acres in 2005-06. It was also noted that rice total sown area was increased by about 20,000 acres over ten years.

The information contained in Table 4 features the change in type of black gram cultivation. The data of 10 year-analysis showed that, among the three sowing practices, Ye-lite-pe ranged from 10-37 % and Khoke-phone-pe 12-41 % while Htun-pe ranged from 22-78 %. It was also noted that, in Maubin Township, Htun-pe was practiced most, followed by Khoke-phone-pe and Ye-lite-pe, respectively. The reason was that most farmers think that Htun-pe gave the highest yield while Khoke-phone-pe the intermediate and Ye-lite-pe the lowest. However, some farmers practice Khoke-phone-pe and Ye-lite-pe than Htun-pe more because of their low input and low management practices.

Table 3. Trends of monsoon rice and black gram cultivation in Maubin Township during ten consecutive years (1996 – 2006)

Year	Rice Growing Areas (Acres)				Black gram area (Acres)	Black gram %
	Yetawm-oetaw (high-land)	Yegyi Kwin(low-land)	Yenet kwin (flooded-land)	Total area (Acres)		
1996-97	76,506	14,078	26,932	117,516	35,788	30
1997-98	76,506	14,078	26,758	117,342	46,696	40
1998-99	76,506	14,078	27,129	117,713	43,258	37
1999-00	76,506	14,078	36,959	127,543	43,109	34
2000-01	76,506	14,078	42,447	133,031	42,442	32
2001-02	76,506	14,078	43,408	133,992	44,913	34
2002-03	76,506	14,078	43,406	133,990	45,503	34
2003-04	76,506	14,078	43,517	134,101	48,064	36
2004-05	76,506	14,078	47,520	138,104	57,835	42
2005-06	77,172	14,917	47,839	139,928	83,789	60

Source: Myanma Agriculture Service, Maubin Township

Table 4. Trends in sowing practices of black gram cultivation after monsoon rice in Maubin Township during ten consecutive years (1996 – 2006)

Year	Black gram Area (Acres)			Yelite%	Khoke- Phone %	Htunpe%
	Yetawm-oetaw (high-land)	Yegyi Kwin(low-land)	Yenet kwin (flooded-land)			
1996-97	76,506	14,078	26,932	117,516	35,788	30
1997-98	76,506	14,078	26,758	117,342	46,696	40
1998-99	76,506	14,078	27,129	117,713	43,258	37
1999-00	76,506	14,078	36,959	127,543	43,109	34
2000-01	76,506	14,078	42,447	133,031	42,442	32
2001-02	76,506	14,078	43,408	133,992	44,913	34
2002-03	76,506	14,078	43,406	133,990	45,503	34
2003-04	76,506	14,078	43,517	134,101	48,064	36
2004-05	76,506	14,078	47,520	138,104	57,835	42
2005-06	77,172	14,917	47,839	139,928	83,789	60

Source: Myanma Agriculture Service, Maubin Township

Table 5. Estimated enterprise budget for Ye-lite-pe in Maubin Township, 2005-06

Operation	Requirement	Rate (Kyat)	Kyat/ acre
Cultivation			3,000
Broadcasting	1 person	500	500
Weeding	3 person	500	1500
Pesticide Application	2 person	500	1000
Inputs			14,100
Seed	12 pyi	1000	12000
Rhizobium	2 packet	50	100
Pesticides	1 bottle	2000	2000
Harvest			9,000
Harvesting	6 persons	500	3000
Transport to thresh floor	2 person	500	1000
Threshing		5000	5000
Total cost			26,100
Yield per acre		8 basket	
Price		12000 kyat	
Gross benefit			96,000
Net benefit			69,900
Benefit-cost ratio			3.7

Source: Myanma Agriculture Service, Maubin Township

Table 6. Estimated enterprise budget for Khoke-phone-pe in Maubin Township, 2005-06

Operation	Requirement	Rate (Kyat)	Kyat/ acre
Cultivation			7,000
Broadcasting	1 person	500	500
Cutting Rice-residue		4000	4000
Weeding	3 person	500	1500
Pesticide- application	2 person	500	1000
Inputs			12,100
Seed	10 pyi	1000	10000
Rhizobium	2 packet	50	100
Pesticides	1 bottle	2000	2000
Harvest			9,000
Harvesting	6 person	500	3000
Transport to thresh-floor	2 person	500	1000
Threshing		5000	5000
Total Cost			28,100
Yield per acre		10 basket	
Price		12000	
Gross benefit			120,000
Net benefit			91,900
Benefit-cost ratio			4.3

Source: Myanma Agriculture Service, Maubin Township

In order to give more specific information for the comparative purposes, general production costs and returns for different production system are shown in Tables 5, 6 and 7. The estimate enterprise budget indicates that Khoke-phone-pe gave the greatest benefit- cost ratio of 4.3 while Ye-lite-pe and Htun-pe contributed benefit-cost ratio of 3.7 and 3.6 respectively. It clearly shows that "Khoke-phone-pe and Ye-lite-pe" can give as much net return as "Htun-pe". This explains why farmers in these regions widely adopt their traditional practice of "Khoke-phone-pe and Ye-lite-pe".

Table 7. Estimated enterprise budget for Htun-pe in Maubin Township, 2005-06

Operation	Requirement	Rate (Kyat)	Kyat/ acre
Cultivation			18,000
Ploughing	3 person	2500	7500
Harrowing	2 person	2500	5000
Da-gyan-tone	1 person	2500	2500
Broadcasting	1 person	500	500
Weeding	3 person	500	1500
Pesticide- application	2 person	500	1000
Inputs			20,350
Seed	8 pyi	1000	8000
Rhizobium	2 packet	50	100
Pesticides	1 bottle	2000	2000
Urea	¼ bag	17000	4250
Triple super phosphate	½ bag	11000	5500
Bio-super foliar	1 bottle	500	500
Harvest			11,000
Harvesting	10 person	500	5000
Transport to thresh floor	2 person	500	1000
Threshing		5000	5000
Total Cost			49,350
Yield per acre		15 basket	
Price		12000	
Gross benefit			180000
Net benefit			130,650
Benefit-cost ratio			3.6

Source: Myanma Agriculture Service, Maubin Township

Note: 16 pyis = 1 basket, 1 pyi = 4.5 lb = 2.04 Kg, Black gram 1 bsk = 72 lb = 32.65 Kg, 1 hectare = 2.471 acres

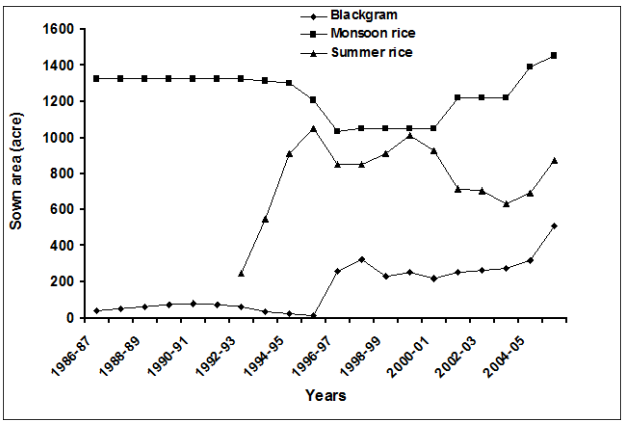

Fig. 4. Trends of Double Cropping Areas of Summer Rice and Black gram after Monsoon Rice during 20 years in Alangyi Village Tract, Maubin Township

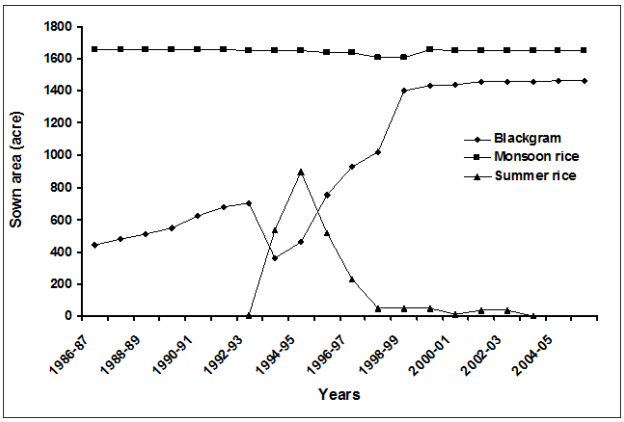

Fig. 5. Trends of the double cropping areas of rice and black gram during 20 years in Ngagyigayet village tract, Maupin Township

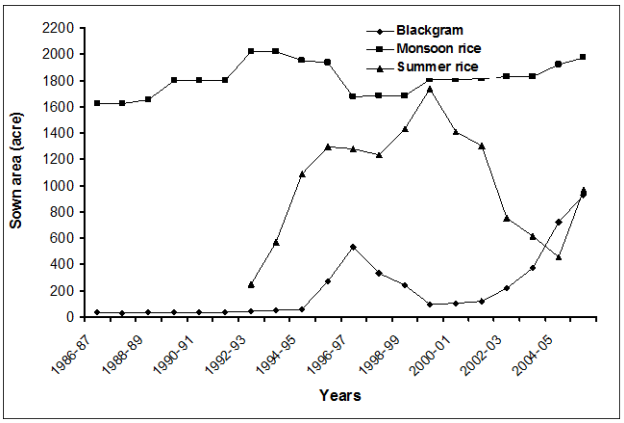

Fig. 6. Trends of Double Cropping Areas of Summer Rice and Black gram after Monsoon Rice during 20 years in Kyonesoke Village Tract, Maubin Township

Table 8. Estimate Enterprise Budget for Summer Rice (Pre-monsoon) in Maubin Township, 2005-06

Operation	Requirement	Rate (Kyat)	Ks/ acre
Cultivation			41,000
Seedbed preparation	-	-	5000
Land preparation			20000
Seedling-uprooting	3 person	3000	9000
Transplanting	14 person	500	7000
Management			16,000
Weeding	6 person	500	3000
Fertilizer application	2 person	500	1000
Pump irrigation	3 times	4000	12000
Inputs			49,500
Seed	3 bas	2000	6000
Urea	ket	17000	17000
Triple super phosphate	1 bag	11000	5500
Murate of potash	½ bag	20000	5000
Diesel oil	¼ bag	3200	16000
	5 gallon		
Harvest			20,000
Harvesting	-	6000	6000
Transport to thresh-	1 pers	1000	2000
floor	on	100	12000
Threshing	120		
	basket		
Total Cost			126,500
Yield per acre	120 basket		
Price		1700	
Gross benefit			204000
Net benefit			77,500
Benefit-cost ratio			1.6

Source: Myanma Agriculture Service, Maubin Township

Figs. 4-6 describe the trends of double cropping patterns during twenty years in A-lan-gyi, Nga-gyi-gayet and Kyone-soke village tracts in Maubin Township respectively. It can be seen that, in some areas, instead of growing black gram, summer rice has been introduced after monsoon rice since 1992-93. The sown areas of summer rice were fluctuated and have been decreasing during the last 7-8 years in these regions. Since 1996-97 the black gram areas have been increasing in A-lan-gyi and Nga-gyi-gayet village tracts. However, in Kyone-soke village tract, the black gram areas decreased during 2000 to 2002 and after that the areas increased again. Under the current production level and marketing environment, benefit-cost ratio of summer rice in 2005-06 in Maubin Township was 1.6 as shown in Table 8, which was much lower than that of black gram. Farmers prefer black gram growing because of its high price, low input and low management requirement to summer rice growing.

Conclusion and Recommendation

Research evidences have well documented that the double cropping or crop rotation of "Monsoon Rice-Post monsoon Black gram" has more positive impacts than "Monsoon Rice-Summer Rice" and "Monsoon Rice-Post monsoon Fallow" pattern. The research carried out at Department of Agricultural Research, Yezin, Myanmar reported that rice - black gram-rice pattern gave greater positive balance of nitrogen than rice-fallow-rice pattern. It supported that legumes in the rice-based cropping systems has positive N contribution (Phyu Pya Lwin *et al.*, 2006). Rego and Seeling (1996) also mentioned that legume crop left the higher amount of N than that of non-legume crop and N uptake of cereal crops growing after legume became higher due to the increasing N availability.

Intensive rice cultivation has been carried out for many decades in Myanmar for domestic consumption and export market. Mono-cropping pattern of rice-fallow pattern is most prevalent in rain-fed rice ecosystem which results in nutrient mining. In this regard, inclusion of pulses in the farmers' cropping systems will surely sustain the soil fertility and reduce the requirement of chemical fertilizers. It is because rice crop benefits from nitrogen fixed through the *Rhizobia*-legume association. Besides, the crop rotation of rice and black gram keeps disease and insect population under control. In large areas of Myanmar the non-availability of irrigation water and delay in vacating the field after rice does not permit double cropping in post monsoon season. Planting of the next crop is not feasible because the top soil layer will dry out soon and no sufficient residual soil moisture will remain if the land preparation is done for the next crop at the time of rice harvest. Under such condition, double cropping of black gram with zero tillage (Ye-lite–pe" or "Khoke-phone-pe) can convert these mono-cropped areas, and thus increase pulse production and sustain the productivity of rice-based system.

"Khoke-phone-pe" is more beneficial than "Ye-lite-pe" or "Htun-pe" because mulching of rice straw- residues conserves soil temperature and moisture, and protects the soil against erosion. It also increases organic matter to the soil which consequently improves the soil's physical condition, and enhances biological activity and soil

fertility. More than 50 % of total rice areas in Myanmar still remain fallow during post monsoon season mainly due to the lack of residual soil moisture. If these areas are tapped for extending pulses cultivation with great efforts on research, pulses areas can be doubled.

The estimated enterprise budget of black gram production in Maubin Township, 2005-2006 indicates that "Khoke-phone-pe" gave the greatest benefit- cost ratio of 4.3 while "Ye-lite-pe" and "Htun-pe" contributed benefit- cost ratio of 3.7 and 3.6 respectively. Therefore these two traditional farmers' practices of "Khoke-phone-pe" and "Ye-lite-pe" have a great potential in rice-based system and it should be introduced into the other possible regions. The results of this survey research will make a preliminary contribution towards identifying the location-specific research and agricultural development needs. Further research should be done in the other regions where temperatures are moderate during winter for black gram growing in rice fallows, emphasizing on the identification of areas with potential to expand pulses production in Myanmar.

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J. Agrofor. Environ. 11 (1 & 2): 115-121, 2017 ISSN 1995-6983

Rural urban migration and rural depopulation in Ayeyarwady region: a case study of three villages in Pyarpon township

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Abstract: Rural urban migration is gaining momentum in Ayeyarwady Region and people from rural area move to urban area to get higher income and better living standard. Agriculture is a major economic activity of the area but local people do not get sufficient income. Like other rural areas in developing countries, economic reason is a major cause that forces people move to the urban area. In the study area, permanent, temporary and seasonal migrations are found and among them, temporary migration is more pronounced. Number of female migrants is higher than that of males due to labour requirement of textile factories in Industrial Zones within Yangon Region. Most migrants are in the age group between 20 and 30 years. Education level of the migrants is low and they earns as casual labour. Although they move to the urban area with the intention of supporting the family, more than half of the migrants do not support regularly because of low income and high cost of living in urban area. Problem on rural depopulation is indistinct due to high birthrate of rural area in the last thirty years ago. This paper tries to find out the causes of migration, to examine the socio-economic characteristics of migrants and to explore problem related to rural depopulation of the area. To present this paper, primary data were collected by using semi-structured interviews and Focus Group Discussion (FGD) was mainly applied. To present the paper, qualitative and quantitative mixed method was applied.
Key words: Causes of migration, types of migration, socioeconomic conditions of migrants, problem on migration.

Introduction

The migration of labor from rural to urban areas is an important part of the urbanization process in developing countries**.** In Myanmar, three types of migration are generally found. Permanent migration is considered to be permanent when migrants have left their origin place for ever and settled in the destination place (with or without registering with the authorities). They do not intend to return to their original place of residence. Temporary migration is considered to be temporary, when an individual or household (fully or partly) settles in the destination location throughout the year, but still has the intention to return to the original place of residence. Seasonal migration is considered to be seasonal, when it takes place only in a certain time of the year or when the migrants return to their places of origin at least once a year (Nyi, 2013).

In Myanmar, rural population was 73 percent of the total population in 2000, and it decreased to 65 percent in 2015 even although fertility rate of rural area is distinctly higher than that in urban area (World Bank, 2015). It somehow highlights rural urban migration is gaining momentum in Myanmar. Like other developing countries, low and irregular agricultural income, agricultural unemployment and underemployment are considered as basic factors pushing the migrants towards developed area with greater job opportunities in Myanmar.

Most of the studies indicated that migration is primarily caused by economic factors. World Bank (2014) expressed that the Ayeyarwady Region have been high levels of migration in recent years, especially since Myanmar's economic transition started in 2011. One in four households in Ayeyarwady has a family member living as a migrant away from home. Fifty-eight percent of migrants move to Yangon Region due to greater job choice caused by urbanization. Rural urban migration is found as a consequence of economic hardship and low living standard in Pyapon Township although there are also few people moved from the native place to other areas because of education and health reasons.

In Pyapon Township, rural urban migration is gaining momentum and economic reason plays important role in migration. Permanent, temporary and seasonal migration patterns are found in internal migration; both men and women migrate, while internal migration is mostly female dominated.

There are several factors such as technological improvements in agricultural production and decreasing returns of agriculture, etc driving migration and rural depopulation (Australian Government Department of Families, Housing, Community Services and Indigenous Affairs. Communities, 2006). As part of the rural area, 70 percent of the people live in rural area and engage in agriculture in Pyapon Township (Regional Facts of Pyapon Township, 2015). Agricultural machineries are now used in cultivation and working period in agriculture is getting short. Most local people become underemployment and they do not get income in off-time period. Therefore, they migrated to urban area.

According to survey, most of the migrant are landless and some earns as casual labour by earning as carpenters, fishermen, tradesmen, etc in Pyapon Township. They do not get regular income that is important for the family's survival. Therefore, one or two of family members especially father, eldest or youngest son or daughter move to other area to earn higher income.

Young people migrated from rural areas to seek employment in the urban areas where economic activities are concentrated and income level is higher. Although rural young adults move to urban areas, they are low skilled labour and they do not get high income. They work as daily waged workers or casual labour. As their skill and daily income are low, they usually move to one work place to another for searching better work and higher income.They are low skilled workers and they easily get jobs. They move from one factory to another owing to low income, social affairs, etc.

In the study area, although the migrants move out from the home land, as they did not take out from the family registration and they stayed as temporary residents in the destination places. Therefore, it is difficult for portraying

rural depopulation. Problem on rural depopulation is not much less intense due to high fertility rate of rural area in the last 30 years. Problem of old aged persons is not also found due to low life expectancy. Life expectancy is low in Ayeyarwady region. Permanent land abundant is not also found because one or two family members moved to urban area and other family members work in agriculture. But, problem on rural depopulation will become pronounced intense due to high rate of migration.

Therefore, most migration caused by economic reason has become more pronounced in the study area but socioeconomic condition of the family left in the rural area is not improved.

Pyapon is one of the 26 townships in Ayeyarwady region within Deltaic area. Pyapon Township is located in the western part of Pyapon district.

It lies between 15° 50 ′ and 16° 25 ′ north latitudes and also between 95°30 ′ and 95°45 ′east longitudes (Fig. 1). It is 64 miles away from Yangon region. The area is 587.303 sq. miles and it is composed of 2 towns, 18 wards and 52 village tracts in which 166 villages are included (Fig. 2).

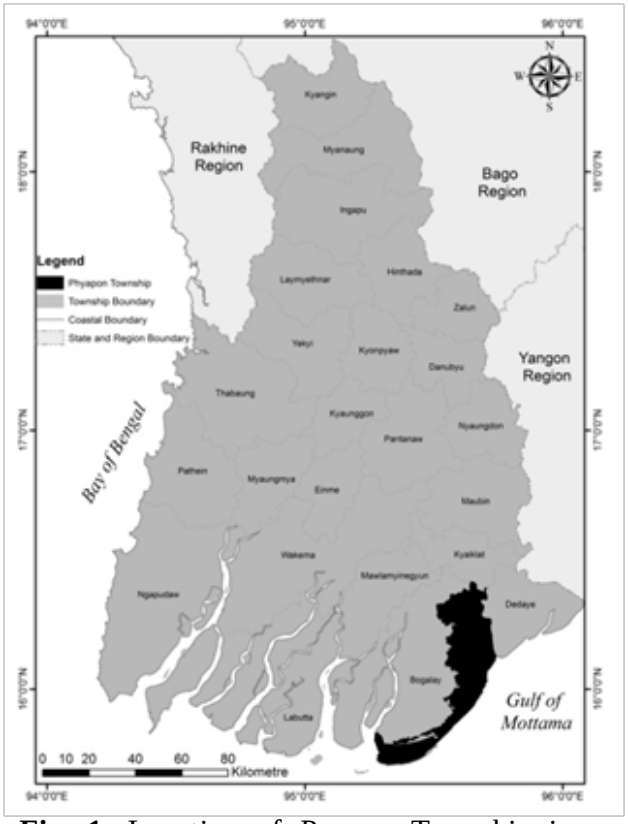

Fig. 1. Location of Pyapon Township in Ayeyarwady Region, Source: Agriculture Atlas, 2002

Its relief is alluvial plain. The elevation is nearly 3 meter (8 ft) above the mean sea level. Two-thirds of the township is lower valley land. Therefore, agriculture is one of the major economic activities of the area. There are many streams and distributaries in the township, being deltaic low land and most people earn as fishermen. In the area, copra making is also found because of existing coconut farm. The objectives of the study are to find out

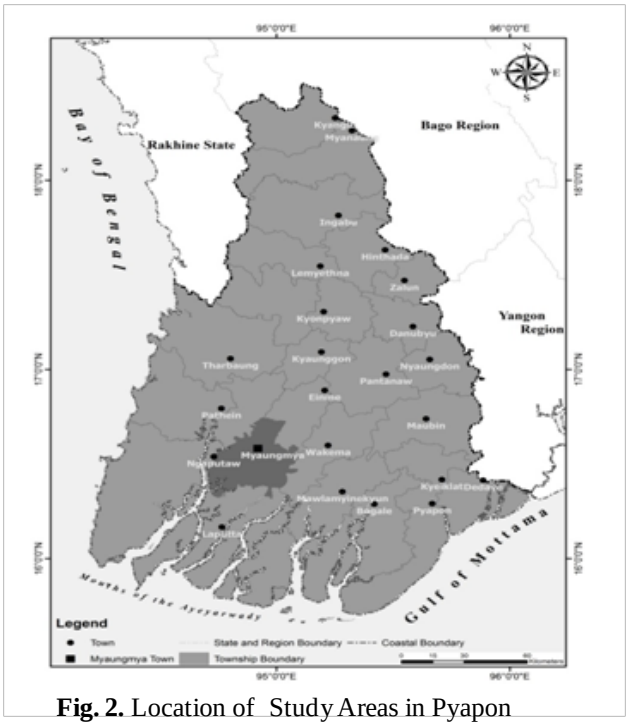

Fig. 2. Location of Study Areas in Pyapon Township; Source: MIMU

the causes of migration, to understand pattern of migration, to examine reimbursement of migrants and to explore problems related to rural depopulation of the area.

Materials and Methods

In Pyapon Township, Kondaing, Yoekone and Mingalar Thaungdan villages were chosen as case study areas because thirty percent of the households have one or more migrants. To get thorough understanding on socio-economic conditions of migrants, migrant profiles such as age, education level, income, social contacts, job opportunities, etc. were collected. Although the major economic activity is agriculture in the area, fishing and copra making are second most important economic activities respectively.

In 2015, 92 (28%) out of 320 households in Kondaing Village, 72 (24%) out of 295 households in Yoekone and 73 (30%) out of 220 households in Mingalar Thaungdan had one or two migrant workers.

Primary data were gathered by using questionnaires. Nine households from three villages were interviewed and questionnaires were distributed to 237 households in three villages. The answers of one hundred and fifty-five questionnaires were applied to present the research work.To get overview on migration and rural depopulation in Pyapon Township, Focus Group Discussion (FGD) was conducted with the help of authorities concerned from General Administrative Department, Staff of Agriculture Department and heads of the villages. In the paper, primary data was chiefly applied and quantitative and qualitative mixed method was mainly used.

Rural urban migration: Rural urban migration is distinct in the area and most migrants moved to other urban areas to get better life and higher job opportunities.

Industrial zones in Yangon region have become focal point that absorb people from rural areas to come, settle, and work. The industrial sector is expanding and job

opportunities increase in the urban area especially in Yangon Region, young adults of the rural area moved to urban areas and in this way the rural-to-urban migration is gaining momentum. Rural to urban migration is an inevitable result of industrialization in the urban area. Economists expressed that rural to urban migration as a process of labor movement from less-developed to more advanced areas.

The number of migrants has been increasing (Fig. 3). The increase in number of migrant is higher in Kondaing Village because more than half of the migrants are landless and they earns as casual labour. The increase in number of migrant is lower in Yoekone Village because copra making is done as second economic activity that can provide job year round basis although the income is low and irregular.

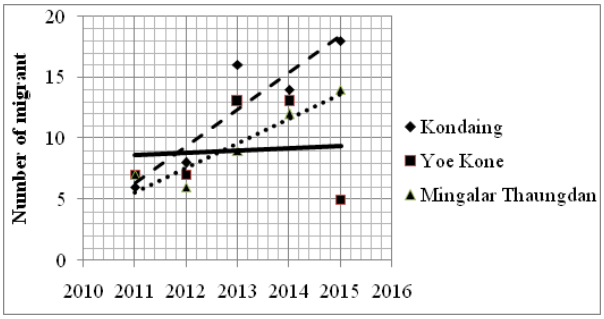

Fig. 3. Migration of Study Areas; Source: Field Survey (2015, 2016)

Types of migration- International and internal migration: Bunea (2012) stated that migration is not a random process. It is a rational choice that implies two decisions: to migrate and where to migrate and the longer the distance, the lower the incentive to migrate due to higher migration costs. In the study area, both internal and international migrations are found. But internal migration is more common in the area due to lack of knowledge and investment to go abroad as well as low skills.

Only six percent is international migrant that moved to abroad especially to Thai, Malaysia etc. and the remaining ninety-four percent is internal migrants. The number of internal migrants is much higher due to low investment, education level, etc.

Patterns of migration: In the area, permanent, temporary and seasonal migrations are found. Temporary migrants rank first with nearly fifty percent and temporary migrants usually come back to their village once a year during New Year festival due to long holiday (Fig. 4). Number of permanent migrants ranked last. They intended to stay temporarily in the urban area when they moved. Then they got married and they settled in urban area for the purpose of getting higher income and better environment. Seasonal migrants come back to their home place in the cultivation or harvesting periods to help their families. Agriculture needs seasonal labour and some local people work in the urban area in off-farm period. Causal labours that worked in construction work usually come back to their village when the job choice is low in the rainy season.

Causes of migration: Lee (1966) said that the 'push factor' is more important than the 'pull factor'. The difficulties in rural areas, such as poverty, unemployment, crop failures and famine, inadequate social amenities and facilities, and land shortages are driving forces that urge the people in rural area to leave their native area and find a new place to settle and to work. The major causes of rural-urban migration is to search better wages, education, political and social stability, technologies, employment and business opportunities.

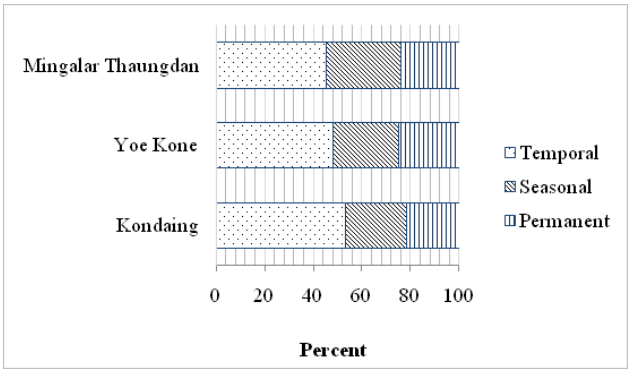

Fig. 4. Patterns of Migration; Source: Questionnaires' results (2016)

Although there are many causes of migration, economic reason is a major cause that forces the rural-urban migration in the area. Varoufakis (2000) said that rural migration is caused by decrease in agricultural working period, lack of employment opportunity outside agriculture, and more economic opportunity in urban areas. Rao (2007) assumed that low income of farm economy and break-down of traditional economic model led to migration and rural depopulation.

Agriculture is major economic activity in Ayeyarwady Region including Pyapon Township. In the area, the traditional mode of labour intensive agriculture changes gradually. Most farmers use agriculture machinery in tilling. It shortens working period and local young adults encounter underemployment problem. In planting period, they practice broadcasting method that needs small amount of labour. Productivity is low because of low investment and salt water intrusion into the paddy field at the end of rainy season. Therefore, agriculture is not a major pillar of the economy in Pyapon Township and it gives low and irregular income. Therefore, local people tried to move to urban areas to get bright sides.

In Pyapon Township, fishing and copra making are second economic activities but they are seasonal job. Fishing is mainly done in the rainy season. Copra making is done throughout the whole year but it is mainly done in the dry season as it is necessary to dry up flesh of the coconut. Landless people work in these second economic activities and these works do not give regular income for their survival.

Works of migrants: Economic hardships and low income are among the factors behind migration. Some people earn as traders who sell foods for local inhabitants and they also do not get sufficient regular income owing to higher cost of living.

In Kondaing Village, nearly eighty percent of local people earns as causal labour because most are land less. Number of causal labour is high with forty-two percent in Yoekone and they mainly work in copra making (Plate 1e and 1f) . Thirty-three percent of the migrants are fishermen in Yoekone and thirty-one percent in

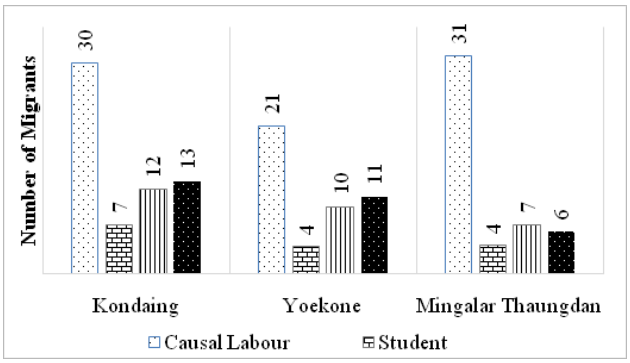

Fig. 5. Works of Migrants in Pyapon Township, Source: Questionnaires' results (2016)

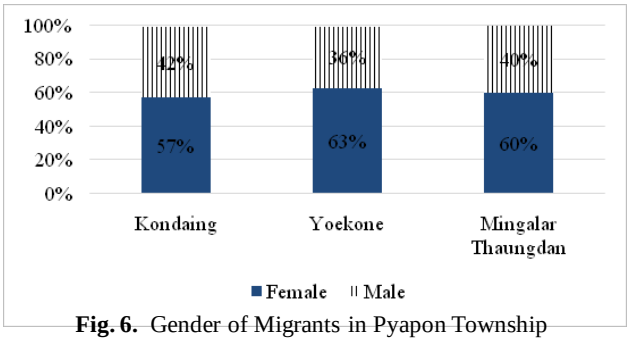

Fig. 6. Gender of Migrants in Pyapon Township Source: Questionnaires' results (2016)

MingalarThaungdan villages (Fig. 5) because these villages are located near the coastal areas and most local people earn at sea as fishermen.The females in these villages work in fish selection at the depot to get daily income (Plate 1c and 1d). These are seasonal work and local people do not get regular income. Therefore, they move to other places for the purpose of getting higher and regular income as well as bright future (Plates 1a-1h).

Profile of migrants

Gender and age groups: Zhao (2003) said that females are much less likely to migrate than males. But in Myanmar, about fifty-two percent were females and forty-eight percent males in 1991 (Nyi, 2013).Similarly, in Pyapon Township, according to questionnaires' answers, number of male migrants exceeds that of male in 2016. More than half of the migrants are female (Fig. 6). It somehow unfolds the female take responsibilities to get income in the rural area. Female labours have greater chance to get jobs in urban area because of growth of factories in the industrial zones of Myanmar.

Number of female is higher because of a greater demand for female labourin factories of Industrial zones (Plate 1g and 1h). There are 23 industrial zone in Yangon region which is nearest to Ayeyarwady region. There are many Joint textile factories in Hlaingtharyar Industrial Zone which is largest industrial zone in Yangon Region and female adults have higher opportunities to work in the factories irrespective of their education.

Plate 1. (a) Machinery use in ploughing , (b) Machinery use in harvesting, (c) Fishing of male workers, (d) Fish selection of female at depot, (e) Copra making of Male Labour, (f) Copra produced from YoeKone Village, (g) Female Labour Requirement of Textile factories in Hlaingtharyar Industrial Zone and (h) Labour Requirement of Shoe factories in Hlaingtharyar Industrial Zone, Source: Questionnaires' results (2016)

Migrants are predominantly young adults from low income families. The largest proportion of migrants falls in the age group between 20 and 30 years. Some adults move to the urban area after finishing their matriculation exam at the age of 16. Factories in Industrial Zone mainly collect the young adults who are between 18 and 30 years old. Table 1 shows that the migrants with the age between 20 and 30 years old ranked first in three cohorts of the migrants (Table 1).

Table 1. Age groups of migrants (2016)

Age group	Kondaing	Percent	Yoekone	Percent	MingalarThaungdan	Percent
>20	25	40%	6	12%	9	20%
between 20-30	35	56%	25	52%	21	47%
>30	3	4%	17	36%	15	33%
Total	63	100%	48	100%	45	100%

Education level: More than half of the migrants in the area are of low education level (Fig. 7). After passing middle school, most of the student left from the school because it is difficult to attend high school due to low family income and far from the high school. In the area, students take more than an hour to get to the high school. Education level of migrants is low but they get the jobs easily because their works are irrespective of their education level and they earn as blue collar workers. According to field survey, most migrants are of basic primary and middle education level because oflow accessibility and less education facilities.

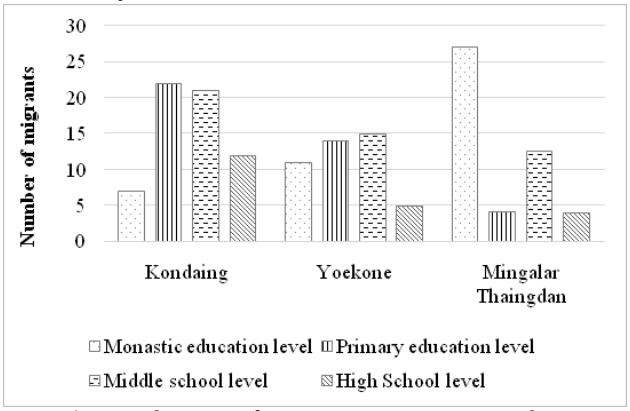

Fig. 7. Education of Migrants in Pyapon Township
Source: Questionnaires' results (2016)

Occupation and income: World Bank (2013) said that migrants mostly find works in informal labor markets in construction sites, restaurants and tea shops in urban areas. A minority enjoy more formal employment in garment factories.

In the area, most male migrants work in construction sites and commercial areas as blue collar labour. Nearly seventy percent of the female migrants work in Industrial Zone, especially in Hlaingtharyar Industrial Zone due to nearness to Ayeyarwady Region. It needs many female workers and they are easy to get jobs. Whoever with the age under 25 has a chance to work there and they get regular income.

According to survey, nearly ten percent of the migrants work as waiters, waitress, house keeper, nanny, etc. in hotels, restaurants and homes and they get a place to stay and food (Fig. 8). They save more money than migrants who worked in construction, trading, etc because of less cost on food.

Income difference depends on skill of the workers. In construction, the income ranges from 4000 ks to 10,000 ks per day due to heavy works. In textile factories, income ranges between 3000 ks and 5000 ks per day. But, most females get 4500 ks per day.

Migrants moved to the urban area for the purpose of getting higher and regular income. Most migrants who work in industrial zones especially factories, etc. get regular income on monthly basis. Some get daily income which is slightly higher than income that was available in the village.

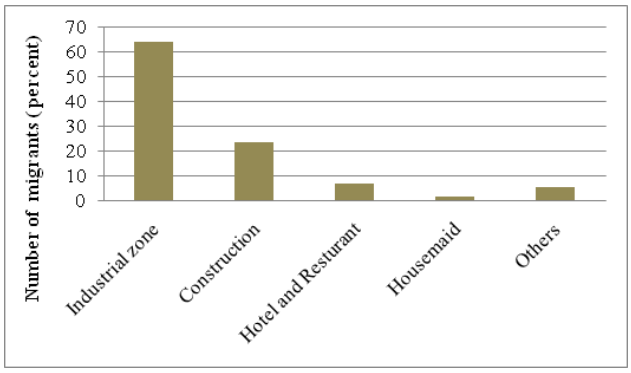

Fig. 8. Jobs of Migrants in Urban Area
Source: Questionnaires' results (2016)

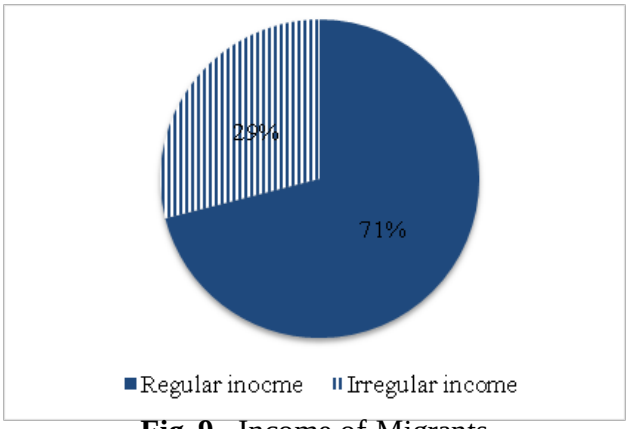

Fig. 9. Income of Migrants
Source: Questionnaires' result (2016)

Some who worked in hotels and restaurants usually get regular income as well as lunch or dinner. Therefore, they can save more to support their family. But, those who work in construction and trading business do not get regular income because construction workers have to move to other places after finishing their work and they are sometimes underemployment.

According to questionnaires' results, seventy-one percent of the migrant get regular income and twenty-nine percent do not get regular income (Fig. 9).

Dwelling: Migrant hoped to live in better environment in the urban area. But, according to questionnaire survey, fifty-three percent of migrants have to live in a rental house or apartment in which nearly 10 migrant stay together. Twenty nine percent of the migrants stays at places provided by the employees. It is hall typed room and more than twenty workers live there. Eighteen percent of the migrant stay at relatives' homes and they have to

pay fee about 10000 ks per month. Restaurants and hotels give rooms to stay to their workers.

Remittance of migrants: All migrants have an intention to support their families but they cannot support their family regularly. About ten percent of the migrants got married in urban area and they became difficult to support their families. Nearly thirty percent of migrants support their families regularly and more than fifty percent of migrants send remittance to their family three or four times in a year (Fig. 10).

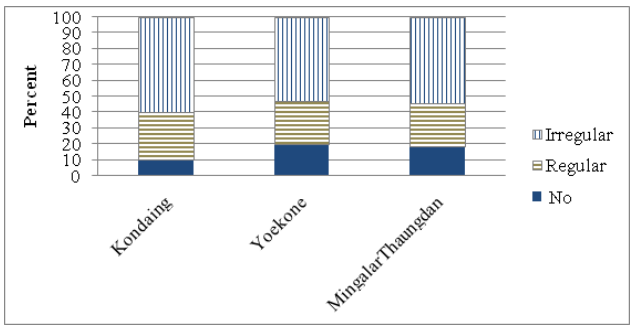

Fig.10. Remittance of Migrants, Source: Questionnaires' result (2016)

They usually send their salary to their families when the younger brothers and sisters enroll the school in June, to pay homage to their parents and for religious festivals in October, when Myanmar New Year is held in April and in the time of emergency for their parents' health.

World Bank (2013) expressed that migrants primarily seek jobs through social networks in their villages rather than through paid brokers. These networks help migrants identify job opportunities and secure accommodation in destination sites in an unknown environment before they leave their village. Massey (1990) also said that the rural urban migration is also controlled by their social networks. Social networks play an important role in decision making on migration. Chain migration is distinctly found in the study area and rural people moved to urban area with the help of the people who was born in the village and live in urban area. They do not pay any fees to them for the help.

According to field survey, mobility of unskilled labour is also found. Fifty-two percent of the migrants have moved from one factory to another within 5-year period due to social affairs, low income and high travel cost.

Moreover, cultural change especially change in dressing style and hair style is found in the area.

Depopulation: Knight (1994) pointed out depopulation has been due largely to the emigration of young people. In Pyapon Township, problems on rural depopulation is still indistinct. It is resulted from high fertility rate of Myanmar in the last 30 years ago. Fertility rate of Myanmar was 4.59 percent, rural 4.87 percent and urban 3.52 percent in 1983 (Myint, 1988). Although one or two family members move to the urban area as temporary migrants, other family members left the rural area and it reduces problem off abandoned land. On the other hand, there is no problem of old age persons due to low life expectancy. In Ayeyarwady region life expectancy was 61.0 in 2014 (CSO, 2014).

Temporary abandoned lands are found because local people do not cultivate their field to reduce amount of capital investment. Permanent abandoned lands are not found in the area as one or two family members moved to urban area and other family members work in agriculture.

Findings and Discussion

Although urbanization in Myanmar during the first decade of the 2000s lagged behind due to Myanmar's economic isolation, urbanization and rural urban migration become distinct after 2010.

In Mandalay, Magway and Sagaingregions, migrants move to Kachin and Shan states (Country Report, 2009). But, migrants of Pyapon Township mainly moved to Yangon Region because of nearness to the area and existing industrial zones.

Reasons for migration include relative poverty, lack of jobs, inability to earn enough money to survive as well as political and/or ethnic conflict in Myanmar (Hall, 2012). In the Dry Zone, most migrants said that the major cause of migration is lack of sufficient employment in the local community (Helvetas Swiss Inter-cooperation Myanmar, 2015). In Pyapon Township, major cause of migration is lack of regular income.

Migration is mainly caused by rural economy that gives low and insufficient income to local people. In the area, internal migration is distinct due to low skill and investment. Three patterns of migration: permanent, temporary and seasonal migration are found.

In Dry zone area, number of male migrants exceeds that of female (Griffiths, 2014). But, number of female migrant is higher than that of male because of work opportunity of females at Industrial Zones. They earn as low skilled labour in urban area due to low education level. Although they moved for the intention of supporting the families, they get low income and they do not get the better environment that they imagined. But, most migrants get regular income. Most migrants live in poor housing and they do not support their family regularly.

Thet (2014) stated that Most of the migrants were aged between 50 and 59 years in Monywa Township. In the study area, most migrant are between 20 and 30 years old and the new generation is not interested in agriculture due to low income and heavy works. Significance of the agricultural sector is gradually losing. It will be the problem in the future because agriculture is major pillar not only for rural people but also food security of the country as deltaic area is rice bowl of Myanmar.

Problems on rural depopulation such as abandoned land, old aged persons, etc are indistinct until now. But, it will be nearly future due to high rate of migration.

Therefore, it is necessary to create alternative job opportunities based on local raw material. In Yoekone Village, coconut is grown and it is suitable to establish the small scale industry that uses coconut, a local raw material. In addition, vocational training centers which based on local raw materials and local economy should be established in the rural areas for training of the productive youths. After finishing vocational school, the youths should be supported with micro loans to set up new small enterprises that in turn create job opportunities for local people and rural development. It is also important to upgrade infrastructure especially roads that are one of the pillars supporting economic growth.

To reduce adverse effects of migration in the future, it is also necessary to do researches on economic potentials of the area, the impact of rural urban migration, the impact of internal migration and economic growth in rural area, education and rural development in Pyapon Township.

Acknowledgements: This paper has been prepared during stay of MyintThida as a visiting scholar of the CSEAS (Center for Southeast Asian Studies, Kyoto University) Fellowship for Visiting Research Scholars 2016 from Nov. 1 2016 to Jan.31.2017. Accordingly, the authors would like to acknowledge institutional supports of Department of Geography, University of Yangon, Myanmar and CSEAS, Japan for conducting the field work and paper preparation. Our thanks also go to the villagers of the study area for their participation during our field work.

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J. Agrofor. Environ. 11 (1 & 2): 123-128, 2017 ISSN 1995-6983

Contribution of NTFPs to local livelihood: a case study of Nong Sai Sub-district of Nang Rong district under Buriram Province in Northeast Thailand

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Abstract: In many areas near forests in rural Thailand, people collect non-timber forest products (NTFPs) for both subsistence and trade. This paper explores the spectrum of NTFPs being collected from dry dipterocarp forests in the Khao Angkhan National Forest Reserve and Khokyai community forest. Villagers in Nong Sai Sub-district of Nang Rong district under Buriram Province were interviewed using a structured questionnaire to examine the contributions of NTFPs to the livelihood and assets of local people. The study parameters included (1) the species of NTFPs collected (2) the seasonal and duration of collection (3) the methods of collection (4) the purpose of collection and (5) the income generated from NTFPs. Villagers perceived the forest's value as a source of goods and services, especially NTFP harvesting. The NTFP collectors generally collected minor products using relatively low-impact indigenous methods. For example, mushrooms were harvested in the morning because they are easier to cook and can be sold for a higher price. Therefore, NTFPs are collected for both subsistence and commercial purposes. Common NTFPs for subsistence use consisted of mushrooms (16 species), wild vegetables (15 species), wild fruits (18 species), medicinal plants (20 species), fuel wood (five species), insects and their products (three species), and wildlife (seven species). NTFPs collected for trade included mushrooms (seven species), wild vegetables (five species), and insects and their products (one species). Overall patterns of NTFP use indicated that the forest makes positive contributions to the lives of people living in and around in terms of both subsistence and cash income but that NTFP collection creates both positive and negative incentives with respect to forest conservation and management if users ignore regulations for sustainable use.
Key words: Non-timber forest products (NTFPs), dry dipterocarp forest, local livelihood, Northeast Thailand.

Introduction

For traditional peoples, the forest serves as a convenience store, grocery, pharmacy, hardware outlet, lumberyard, and department store (Bennett, 2002), and the importance of forest products to households living in or near forests has been increasingly recognised. Estimates of the number of people who in some way rely on forests, for either survival or livelihood, vary widely (Byron and Arnold, 1999), especially with respect to non-timber forest products (NTFPs). NTFPs which have long been considered "minor" or "secondary" forest products, are defined as any tangible animal or plant products other than industrial timber that can be collected from forests for subsistence and trade (Ros-Tonen *et al*., 1995). Thus, the NTFP category includes wild plants for food (including food for domesticated animals), game, medicinal herbs, small-scale wood for tools and handicrafts, latex for rubber, and building and dying materials (De Beer and McDermott, 1989). NTFPs are central to interactions between local people and forests, and help to sustain rural livelihoods through subsistence and commerce (Anderson, 1993; Sato, 1998; Satien-Thai, 1999; Sharp *et al*., 1999). NTFP use is less ecologically destructive than timber harvesting, encouraging the belief that more intensive management of forests for such products could contribute to both development and conservation objectives (Michael Arnold and Ruiz Pe´rez, 2001). Consequently, conservationists and environmental economists have promoted the extraction of NTFPs as an alternative to forest conservation and as a benefit to those who are reliant on forests (Bennett, 2002). Therefore, understanding NTFP use is a prerequisite to motivating subsistence-level forest users to enrich and manage the forests on which they rely.

Northeast Thailand, known as Isaan, contains some of Thailand's the highest populations, but is also the poorest part the country (Grandstaff *et al.*, 2008). Forest cover accounts for 16.32% or 27,555.54 km^2 of the region's overall area, of which about 1,505 km^2 is community forest (Royal Forest Department, 2009). Most people in the region are farmers whose livelihoods are connected to the forest in terms of both traditional cultural practices and food acquisition. NTFPs are a critical component in the subsistence of farmers and play an essential role in the rural diet of Northeast Thailand. In the past, research on NTFPs in Northeast Thailand focused *on ethnobotany and NTFP use and diversity (Somnasang et al*., 1988; Somnasang *et al*., 1998; Wester, 1996; Prachaiyo, 2000), while a small number of studies examined the potential for NTFPs to modernise modes of subsistence in southern Isaan. Clearly, NTFPs are not limited to household consumption but are also used to generate secondary income. Generally, academic understanding of the role and potential of NTFPs to contribute to capital accrual and poverty alleviation is based on case studies, which hold little value in terms of generalisation (Marshal *et al.*, 2003; Belcher *et al.*, 2005; Ros-Tonen and Wiersum, 2005). Hence, questions remain about whether, or to what extent, NTFPs contribute to local livelihoods, community development and forest resource conservation. Thus, we selected the dry dipterocarp forest in Khao Angkhan national forest reserve and Khokyai community forest in Buriram for our study because they are important sources of NTFPs for the region's rural residents. We report a preliminary study of NTFP contributions to local livelihood, and include general information on NTFP species, use, and objectives of collection.

Materials and Methods

Study area: Our study took place in four districts of the Khao Angkhan National Forest Reserve (locally known as the Khao Angkhan conservation forest area) and Khokyai community forest-Nang Rong, Lahansai, Chaloem Phrakiat, and Pakham- in Buriram Province, Northeast Thailand (Fig. 1). The region comprises dry dipterocarp forest with an area of about 51 km^2, bounded mainly by agricultural land and settlements. The elevation is about 200 meters above mean sea level. The area is dominated by a tropical seasonal monsoon climate, with three marked seasons: hot, rainy, and dry. The mean monthly

temperature is 31.5°C (min. 24°C, max. 34°C), with extreme high of 40°C or more in April and May. The mean annual rainfall during the monsoon)June-October) is about 1,000 mm, and the mean monthly humidity is 70%.

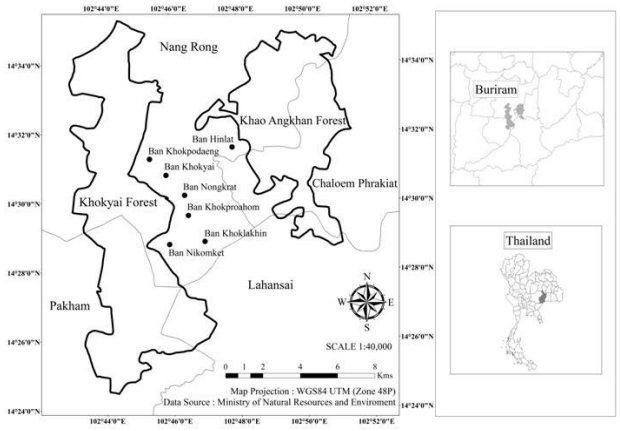

Fig. 1. Geographical position of study area

The population of the study area in 2009 was 6,556 (3,253 males and 3,303 females) with a population density of 80.93 km^{-2} unevenly distributed around the forest. Agriculture is the main occupation of ~80% of forest inhabitants, with rice and cassava the main crops. Rearing animals such as chickens and cattle is common in most households.

Methods: Field data collection comprised two parts. First, we used questionnaires to interview household representatives, completing a total of 150 interviews with participants from seven villages: Hinlat, Khokyai, Khokpodaeng, Nongkrat, Khokprohom, Khoklakhin, and Nikomket in Nong Sai Sub-district, Nang Rong District, Buriram Province. Second, we used a participatory rural appraisal approach (PRA), including interviews with village NTFP buyers ("middle men"), using semi-structured interviews and group discussions and meetings to ascertain NTFP use, particularly of NTFPs collected for commercial purposes.

All field survey data were synthesised and analysed using the Statistical Package for Social Science for Windows (SPSS). The programs were used to analyse general information from the respondents' households, and content analysis was used to analyse the PRA data.

The names of the various plant and animal species that the villagers collected were originally given as local names; these were changed to common and scientific names using a variety reference books and consultations with local experts.

Results and Discussion

Sociodemographic and economic characteristics of the community: In the field survey, 63% of respondents were female, and the overall average age of respondents was 46. Most respondents had completed primary school and were born in the study area. Most respondents were farmers, generally producing Thai jasmine rice and cassava. Some had established agroforestry systems, cultivating various species of plants and animals for household consumption and selling surplus products to generate income. The main income of the villagers was derived from agricultural products such as Thai jasmine rice and cassava; average household income from agriculture was about 50,941 Baht (USD 1,491.7) per year. Other important sources of income included wage labour and NTFP trade, together averaging about 35,108 Baht (USD 1,028.1) per year per household The average total household income in the target villages was 86,049 Baht (USD 2,519.7) per year. However, most respondents stated that their income was insufficient, and 77% had debts. Loans were mainly obtained from village funds, and were used to purchase agricultural supplies and to cover necessary daily expenses.

Land tenure: Most respondents occupied land and possessed land certificates such as title deeds (Nor Sor 3), or certificates of local maintenance tax (Por Bor Tor 5). The average size of land holdings was about 1.3 ha. More than half of respondents wanted to expand their holdings, mostly to accumulate land for their children.

Villager dependency on the Khao Angkhan and Khokyai forests: As mentioned, villagers in Nong Sai Sub-district perceived the value of the forest as a source of various goods and services such as recreation, watershed functions, and NTFPs. Most villagers stated in their interviews they collected NTFPs for both subsistence and commerce. NTFP provision is the main function of Khoa Angkhan and Khokyai forests, according to the villagers.

Mushrooms, wild vegetables and fruits, medicinal plants, fuel wood, insects and their products, and wildlife were collected for subsistence use. NTFPs collected for trade included mushrooms, wild vegetables, and insects and their products.

Collection of NTFPs for subsistence use: NTFPs play an important role in the livelihood of villagers in Nong Sai Sub-district. Many species of NTFPs were harvested for daily use as food, medicine, and energy production. NTFPs for household consumption were classified as follows:

Mushrooms: Sixteen species in six families were collected, including Hed Ta Khai (*Russula delica*), Hed Ra Ngok (*Amanita princes*), Hed Kone (*Termitomyces spp*.), Hed Phek (*Lentinus strigosus*), Hed Nam Paeng (*Russula alboareolata*), and Hed Tan (*Russula densifolia*). A complete list of mushroom species is given in Table 1. Usually, villagers collected mushrooms during the rainy season from June to September; less often, mushrooms were collected 2-3 days after isolated rains throughout the hot season (April-October). The precise areas of mushroom collection varied according to the target species. Usually, villagers collected mushrooms, especially Hed Kone, in the same places each year. The average quantity of mushrooms collected is shown in Table 2.

Wild vegetables: Fifteen species from 12 families were collected, including Dog Din (*Hitcheniopsis parviflora*), Buk I Rok (*Pseudodracontium lacourii*), Phak wan (*Melientha suavis*), I Noon (*Adenia viridiflora*), and Krachiao (*Curcuma singularis*). A complete list of wild vegetable species is given in Table 1. Villagers collected wild vegetables all year, with some species, such as Dog Din and Krachiao, available only in the rainy season. The average quantity of wild vegetables collected per household is shown in Table 2.

Table 1. NTFPs collected from Khao Angkhan National Forest Reserve and Khokyai community forest, Nong Sai Sub-district, Nang Rong District, Buriram Province.

Type of NTFPs	Thai Name	Scientific Name	Family	Purpose of Collection		Collecting Duration
				Subsistence	Commercial	
Mushroom	Hed Ra Ngok	*Amanita princeps* Corner & Bas	AGARICACEAE	✋	✋	Apr-Sep
	Hed Kone	*Termitomyces* spp.	AGARICACEAE	✋	✋	Apr-Nov
	Hed Nang Hong	*Amanita caesarea* (Scop.) Per.	AGARICACEAE	✋	✋	Apr-Sep
	Hed Khai Han	*Amanita vaginata* (Bull.) Lam.	AGARICACEAE	✋	-	Apr-Sep
	Hed Saiduean	*Amanita* sp.	AGARICACEAE	✋	-	Apr-Sep
	Hed Chamuk wau	*Lactarius turpis (Weinm.) Fr.*	BOLETACEAE	✋	✋	Apr-Sep
	Hed Phueng	*Boletus colossus* Heim	BOLETACEAE	✋	-	Apr-Sep
	Hed Nam Manpu	*Cantharellus* sp.	CANTHARELLACEAE	✋	-	Apr-Sep
	Hed Pho	*Astreaus hygrometricus* (Pers.) Morgan	LYCOPERDACEAE	✋	✋	Apr-Jun
	Hed Bot	*Lentinus polychrous* Lev.	POLYPORACEAE	✋	-	All year
	Hed Phek	*Lentinus strigosus* (Schwin). Fr.	POLYPORACEAE	✋	-	Apr-Oct
	Hed Nam Paeng	*Russula alboareolata* Hongo	RUSSULACEAE	✋	-	Apr-Sep
	Hed Ta Khai	*Russula delica* Fr.	RUSSULACEAE	✋	✋	Apr-Oct
	Hed Tan	*Russula densifolia* (Sevr.) Gill	RUSSULACEAE	✋	-	Apr-Sep
	Hed Na Lae	*Russula cyanoxantha* Schaeff ex. Fr.	RUSSULACEAE	✋	-	Apr-Sep
	Hed Nam Mak	*Russula emetica* (Schaeff. ex. Fr.) Pers. ex.S.F. Gray	RUSSULACEAE	✋	✋	Apr-Sep
Wild vegetable	Buk I Rok	*Pseudodracontium lacourii* (Linden & Andre) N.E.Br.	ARACEAE	✋	✋	May-Jul
	Makok Pa	*Spondias pinnata* (L.F.) Kurz	ANACARDIACEAE	✋	-	All year
	Prong	*Cycas siamensis* Miq.	CYCADACEAE	✋	-	All year
	Chot	*Vietnamosasa ciliata* (A. Camus) T.Q.Nguyen	POACAEA	✋	✋	Jul-Oct
	Chamuang	*Garcinia cowa* Roxb.	CLUSIACEAE	✋	-	All year
	Tio	*Gratoxylum formosum* (Jack) Dyer	HYPERICACEAE	✋	-	All year
	Kradon	*Careya sphareica* Roxb.	LECYTHIDACEAE	✋	-	All year
	Yanang	*Tiliacora triandra* (Colebr.) Diels	MENISPERMACEAE	✋	-	All year
	Phak wan	*Melientha suavis* Pierre	OPILIACEAE	✋	-	Apr-May
	Kra Thok Rok	*Olex psittacorum* (willd.) Vahl	OLACACEAE	✋	-	All year
	I Noon	*Adenia viridiflora* Craib.	PASSIFLORACEAE	✋	✋	May-Jul
	Thao Wan Yang	*Smilax ovalifolia* Roxb.	SMILACACEAE	✋	-	All year
	Krachiao	*Curcuma singularis* Gagnep.	ZINGIBERACEAE	✋	✋	May-Jun
	Dog Din	*Hitcheniopsis parviflora* (Wall.) Loes.	ZINGIBERACEAE	✋	✋	May-Jun
	Prohom	*Kaempferia galanga* L.	ZINGIBERACEAE	✋	-	All year
Wild fruit	Nom Maeo	*Uvaria rufa* Blume	ANNONACEAE	✋	-	Mar-May
	Nom Noi	*Polyalthai blumecta* (Pierre) finet&gagnep	ANNONACEAE	✋	-	All year
	Tab Tao	*Polyalthai debilis* (Pierre) finet&gagnep	ANNONACEAE	✋	-	All year
	Makok kluean	*Canarium subulatum* Guill.	BURSERACEAE	✋	-	Jun-Dec
	Samo Thai	*Terminalia chebula* Retz.	COMBRETACEAE	✋	-	Jan-Aug
	San Yai	*Dillenia obovata* (Blume) Hoogland	DILLENIACEAE	✋	-	Feb-Jun
	Makham Pom	*Phyllanthus emblica* L.	PHYLLANTHACEAE	✋	-	Jan-Aug
	Mao Khai Pla	*Antidesma ghaesembilla* Gaertn.	PHYLLANTHACEAE	✋	-	May-Aug
	Tako Na	*Diospyros rhodocalyx* Kurz	EBENACEAE	✋	-	Mar-Jul
	Takhop Pa	*Flacourtia indica* (Burm. F.) Merr.	SALICACEAE	✋	-	Jan-Jul
	Kra Bok	*Irvingia malayana* Oliv. Ex A.W. Benn.	IRVINGIACEAE	✋	-	Jan-Apr
	Makha Tae	*Sindora siamensis* Teysm. Ex.Miq.	FABACEAE	✋	-	Mar-Sep
	Wa	*Syzygium cumini* (L.) Skeels	MYRTACEAE	✋	-	Feb-Jun
	Mak Mo	*Rothmannia wittii* Bremek	RUBIACEAE	✋	-	Apr-Jul
	Ma Huat	*Lepisanthes rubiginosa* (Roxb.) Leenh.	SAPINDACEAE	✋	-	Oct-Apr
	Ta Khro	*Schleichera oleosa* (Lour.) Oken	SAPINDACEAE	✋	-	Jan-Aug
	Phlap Phla	*Microcos tomentosa* Sm.	TILIACEAE	✋	-	Apr-Oct
	Kao Tak	*Grewia nisuta* Vahl	TILIACEAE	✋	-	All year
Medicinal plant	Nom Maeo	*Uvaria rufa* Blume	ANNONACECE	✋	-	All year
	Do Mai Ru Lom	*Elephantopus scaber* L	ASTERACEAE	✋	-	All year
	Pak Kad Dab	*Gynura pseudochina* (L.) DC.	ASTERACEAE	✋	-	All year
	Kham Rok	*Ellipanthus tomentosus* Kurz	CONNARACEAE	✋	-	All year
	Prong	*Cycas siamensis* Miq.	CYCADACEAE	✋	-	All year
	San Yai	*Dellania obovata* (Blume) Hoogland	DILLENIACEAE	✋	-	All year
	Ta Ko Na	*Diospyros rhodocalyx* Kurz	EBENACEAE	✋	-	All year
	Makham Pom	*Phyllanthus emblica* L.	PHYLLANTHACEAE	✋	-	All year
	Mueat Lot	*Aporosa villosa* (Lindl.) Baill.	PHYLLANTHACEAE	✋	-	All year
	Mao Khai Pla	*Antidesma ghaesembilla* Gaertn.	PHYLLANTHACEAE	✋	-	All year
	Khan Thong Phayabat	*Suregada multiflorum* (A. Juss.) Baill.	EUPHORBIACEAE	✋	-	All year

Contd.

	Krai Thong	*Erythroxylum cuneatum* Kurz	ERYTHROXYLACEAE	✋	-	All year
	Takhop Pa	*Flacourtia indica* (Burm. F.) Merr.	SALICACEAE	✋	-	All year
	Tio Kliang	*Cratoxylum cochinchinensis* (Lour.)	HYPERICACEAE	✋	-	All year

		Blume				
	Kret Plachon	*Phyllodium pulchellum* (L.) Desv.	FABACEAE	✋	-	All year
	Huad Seo kiew	*Orthosiphon rubicundus* (D.Don) Benth.	LAMIACEAE	✋	-	All year
	Kradon	*Careya sphareica* Roxb.	LECYTHIDACEAE	✋	-	All year
	Hatsakun	*Micromelum minutum* Wight & Arn	RUTACEAE	✋	-	All year
	Plalai Phueak	*Eurycoma longifolia* Jack.	SIMAROUBACEAE	✋	-	All year
	Popae	*Grewia hirsuta* Vahl	MALVACEAE	✋	-	All year
Fuel-wood	Teng	*Shorea obtusa* Wall. Ex Blume	DIPTEROCARPACEAE	✋	-	All year
	Krat	*Dipterocarpus intricatus* Dyer.	DIPTEROCARPACEAE	✋	-	All year
	Phluang	*Dipterocarpus tuberculatus* Taub.	DIPTEROCARPACEAE	✋	-	All year
	Daeng	*Xylia xylocarpa* (Roxb.)	FABACEAE	✋	-	All year
	Makha Tae	*Sindora siamensis* Teijsm. Ex.Miq.	FABACEAE	✋	-	All year
Insects and their products	I Noon	*Holotrichia* sp.		✋	-	All year
	Khai Mot Daeng (Egg of Red Ant)	*Oecophylla smaragdina*		✋	✋	Mar-May
	Phueng (Bees)	*Apisdorsata fabricius*		✋	-	All year

Wild fruit: Eighteen species in 13 families were collected (Table 1). The villagers tended to collect them indirectly as they collected other NTFPs or ran activities in agricultural land, favouring species such as Takhop Pa (*Flacourtia indica*), Makham Pom (*Phyllanthus emblica*) and Samo Thai (*Terminalia chebula*). Villagers collected many wild fruits all year long, especially in the dry season.

Medicinal plants: The villagers have established health centres, but traditional healing practices are still used, and medicinal plants are collected by the community. Most respondents collected medicinal plants for household use, usually for relieving general ailments such as colds, fevers, or stomach ache. Most plants were collected in the forests surrounding the villages. Common medicinal plants were Nom Maeo (*Uvaria rufa*), Hatsakun (*Micromelum minutum*), Kham Rok (*Ellipanthus tomentosus*), and Makham Pom (*Phyllanthus emblica*). A complete list of medicinal plant species is given in Table 1.

Fuel wood: Fuel wood was in demand in the study area as a source of energy. The main sources of fuel wood were villagers' cultivated land and the surrounding forest. Five species of fuel wood were collected, including Daeng (*Xylia xylocarpa*), Teng (*Shorea obtusa*), Makha Tae (*Sindora siamensis*), Krat (*Dipterocarpus intricatus*), and Phluang (*Dipterocarpus tuberculatus*).

Wildlife: The respondents hunted wildlife for household consumption. The main species hunted were ground lizard, other lizards, and birds. Additionally, some respondents indicated that members of their household regularly caught aquatic animals such as fish, bullfrogs, and other frogs for household consumption.

Insects and their products: Respondents collected various insects and insect products, especially the eggs of the red ant (Khai Mot Daeng), which are used for several popular local dishes. Insect products were collected from January to March when ant nests are common on the leaves of *Shorea obtusa*, *Shorea siamensis* and other tree species in the dry dipterocarp forest. Other insects included bees and I Noon (*Holotrichia sp*.).

Collection of NTFPs for commercial use

Agriculture and wage labour are important sources of income, but NTFPs remain important to local livelihoods, especially for women. About 21.4% of NTFPs are consumed in the collectors' households, and the remaining 78.6% sold at market. Various mushrooms, wild vegetables, and insect species and their products were important NTFPs for commercial use (Tables 1 and 2).

Table 2. Average quantity per year and price of NTFPs collected from Khao Angkhan National Forest Reserve and Khokyai community forest, Nong Sai Sub-district, Nang Rong District, Buriram Province.

Thai name	Average Quantity of NTFPs		Average Price* (Baht/kg)	Percent of NTFPs collecting for Commercial/Household
	Subsistence (kg/Household)	Commercial (kg/Household)		
Hed Ta Khai	2.6	7.9	180	75.0
Hed Ra Ngok	0.9	3.6	160	80.6
Hed Kone	2.3	6.2	120	72.7
Hed Nang Hong	0.4	1.3	160	76.0
Hed Nam Mak	2.2	6.2	110	74.0
Hed Pho	2.9	3.7	250	56.7
Hed Chamuk wau	2.6	9.5	120	78.4
Dog Din	2.2	15.6	35	88.0
Krachiao	1.0	6.0	35	85.9
Buk I Lok	1.7	10.9	30	86.7
I Noon	3.0	15.2	30	83.5
Chot	2.8	3.9	100	58.4
Khai Mot Daeng	1.0	3.6	335	79.1
Total	25.4	93.6	-	78.6

* Price during the study period (June, 2009); currency exchange rate: 34.15 TH = 1US$

Mushrooms: Seven species were collected, including Hed Ta Khai (*Russula delica*), Hed Ra Ngok (*Amanita princes*), and Hed Kone (*Termitomyces spp*.). Most collectors sold their mushrooms to village middle-men at prices of 80-200 Baht per kilogram, depending on the species. Usually, mushrooms are collected between 4 and 8 AM, before their heads fully open.

Wild vegetables: Five species were collected, including Dog Din (*Curcuma parviflora*), Krachiao (*Curcuma singularis*), Buk I Lok (*Pseudodracontium lacourii*), I Noon (*Adenia viridiflora*), and Chot (*Vietnamosasa cililta*). Most collectors sold wild vegetables to a village middle-man, who took their products to the district market. The price was 30-35 Baht per kilogram, depending on the species. Usually, wild vegetables are collected between 6 and 8 AM, before the day's heat.

Insects and their products: Only eggs of the red ant were collected for commercial use. The price is about 335 Baht per kilogram. The tools to collect the eggs come from household materials such as bamboo handles, buckets, baskets, and tapioca flour.

The contribution of NTFPs to local livelihood: Our results indicate that the forest makes a positive contribution to local people living in and around the forest, for both subsistence and cash income. Most NTFPs in Khao Angkhan and Khokyai forests were collected for household consumption, and the rest (seven mushroom and five wild plant species, and the eggs of the red ant) were sold. The villagers' main income was derived from agriculture, supplemented by NTFP collection. The dry dipterocarp forest is an important source of expensive and popular NTFPs, including red ant eggs, Hed Pho, Hed Ta Khai, Hed Kone, and Phak Wan.

Phak Wan was not found on the list of commercial species, although it commanded high prices and had high demand. The fact that Phak Wan was only used in household consumption implies that it occurred in quantities insufficient for sale. In turn, this speaks to the forest's health: Phak Wan is normally common in dry deciduous forests, particularly those dominated by *Shorea siamensis* and *Shorea obtusa* (Kerr *et al.*, 1931). We did not focus on forest health, but interviews revealed that the species was formerly very popular, fetching high prices. The villagers scrambled to transplant the Phak Wan trees from the forest to their own properties, but in the process, they cut the roots, killing the trees - a 'tragedy of the commons' scenario (Hardin, 1968). That is, as the population and pressure on resources grew, users of resources held in common tend to overexploit and degrade those resources. Although regulations control forest use and management in the region, strict regulation is not possible as user groups in and outside the villages can easily and covertly access and exploit the forest. Participation in forest conservation was closely related to income generated from NTFP collection (Mianmit, 2003), but evidence suggests that NTFP collection has both positive and negative incentives, as unrestrained and unmanaged collection can have negative impacts on the structure and dynamics of NTFP species populations (Murali *et al.*, 1996; Muraleedharan *et al.*, 2005). Therefore, for the sustainability of NTFP use and forest functions, user groups and community forest committees must work together for forest management.

Most of the respondents interviewed were farmers, with average land holdings of about 1.3 ha. The main income of the villagers was derived from agricultural products such as Thai jasmine rice and cassava. The average household income from agriculture was about 50,941 Baht (USD 1,491.7) per year. Other important sources of income came from wage labour and trading NTFPs, which amounted to an average of about 35,108 Baht (USD 1,028.1) per year per household. Agriculture and wage labour are important sources of income, but NTFPs are still important to local livelihood. From the viewpoint of income generation, NTFPs play complementary roles. Regarding the 51 km^2 of dry dipterocarp forest adjacent to the study villages, respondents perceived its value as a source of goods and services that greatly benefit their livelihood. Of the NTFPs collected from the forest for subsistence and trade, about 21.4% were consumed in the collectors' households, and 78.6% sold at market. Many wild products such as mushrooms (16 species), vegetables (15), fruits (18), medicinal plants (20), fuel wood (five), insects and their products (three), and animals (seven) were collected and hunted from the forest. Among these, seven species of mushroom, five of vegetables, one insect and its products were collected for trade. One exception was Phak Wan. Phak Wan is one of the most important species of NTFPs in dry dipterocarp forest because of its high price and demand in the domestic market, but it is used only locally and not sold at market. Phak Wan likely has high potential to provide income for local communities. Besides domestication, conservation of Phak Wan and its habitats in natural forests is also important for local livelihoods and can be an incentive for villagers to participate in forest conservation in Khao Angkhan and Khokyai forests.

Acknowledgements: We gratefully acknowledge the financial support of the Thailand Research Fund (TRF) and Nong Sai Sub-district Administration Organisation (SAO). The conclusions and opinions expressed in this report are those of the authors and do not necessarily reflect the views of our funding agencies.

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J. Agrofor. Environ. 11 (1 & 2): 129-132, 2017 ISSN 1995-6983

Geo-environmental changes and human activities in Japanese lowland archaeological site

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Abstract: Alluvial lowlands occupy about 13% of the total area of the Japanese Islands, and widely distribute along the coasts and the lower reaches of the rivers. In this paper, attempts have been made to make cemptlear the geomorphic development and regional difference of alluvial lowlands in Japan based on the geographical and the archaeological data. We analyzed the changes of relationship between geo-environment and human activities in lowland archaeological site, central Japan, based on sedimentary facies analysis and pollen analysis. Some conclusions are as follows: (1) Yayoi period, is located in the environment lowland basis, there is no stagnant water permanent, but there is an environment lowland basis floods temporary, such as those generated, peripheral vegetation covered in mainly evergreen forest. (2) Fluvial activity is active at the Kofun period, the ground surface was unstable and the landscape mainly of laurel was formed in the peripheral vegetation. (3) Ground drier is in progress since the Middle Ages, agricultural land development has been progressed.
Key words: Lowland, Geo-environment, pollen analysis, archaeological site, Nobi plain.

Introduction

The disappearance and formation of the archaeological site, it is closely related to the change in short time geo-environmental changes have been pointed out (Takahashi, 2003). These studies is an area that is focused geological and geomorphological data in archaeological sites. In other words, has been possible to consider detailed geo-environmental evolution in alluvial plain from analysis in archaeological site location (Miyamoto *et al*., 2001). It is important to consider the detail change for the study of the landform evolution in alluvial lowland.

From this point of view, the author tried to make clear the change of geo-environemant and human activities in the Nobi lowland (Hirate-cho archaeological site) based on the detail analysis of the recent sediments and and pollen analysis. Then the author discussed on the paleoenvironmental changes and landform evolution of the alluvial plain in the Nobi lowland, central Japan.

Materials and Methods

Geographical Setting: The Nobi Plain underlain by young sediments is situated in the central part of Japan and is about 1800 km^2 in area. This plain faces Ise Bay, where the Ibi, Nagara, Kiso, and Shonai rivers discharge, and is composed of alluvial fans, flood plains, deltaic plains, terraces, reclaimed lands, and filled-up ground.

Hirate-cho ruins, is located in the alluvial lowland of Shonai river, in the lowlands in valleys, and ridges are some extending to the east-west direction are distributed (Fig. 1; Kito, 2004). It is pointed out that the Hirate-cho site is located in the ridge (Palynosurvey, 2006). In the previous study, such as the remains of the medieval moat trace in mid-Yayoi period (*ca*. 400 BC to 50 AD) has been detected. And various natural scientific analysis has also been carried out at the same time (Nagoya Land Development Corporation, 2006). The field survey was carried out primarily in the fourth excavation area mainly.

Sedimentary facies: Fig. 1 shows the surveyed site locality from Umitsu (1991). Soil profiles were observed at various exposures along paths and trench at the trench in archaeological site. The sedimentary facies and structure of each locality were described, and sediment samples were collected for pollen analysis.

Pollen Analysis: Pollen and spore fossils were extracted by the following procedures: Samples of *ca*. 2 g were taken and were treated with 10 % KOH, sieved through a 0.5 mm mesh, decanded to remove organic macro materials, treated with wash and $ZnCl_2$, dehydrated with acetic acid, and treated for 2.5 min. by the acetolysis method. The residue was saturated in 50 % glycerine, and was mounted on glass slide. All pollen and spores on each slide were counted. The percentages of pollen taxa and spore types were calculated based on the total arboreal pollen counts including *Alnus*.

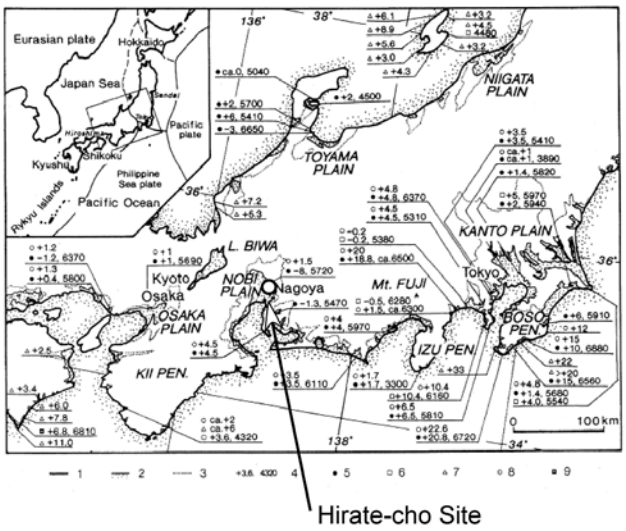

Figure 1. Locality of the Hirate-cho Site, Nobi plain, central Japan (from Umitsu, 1991)

Results and Discussion

Changes in geo-environment and vegetation: Changes in geo-environment and vegetation were discussed on each period based on the results of sedimentary facies and pollen taxa as have been shown in Figs. 2 to 4.

Formation of lowland (Yayoi period; *ca.* 300 BC to AD 300): It is suggested to be a time when by the first 10 to 15 layers shown in Fig. 1 is composed of silty sediments were indicted a temporary small floods repeatedly. It is estimated that the formation time of the deposition, to be a time to mainly Yayoi period including archaeological

remains and reconstructed as the beginning of the dry-up in land. This period is repeated periodically soil of supply and flood sediment by a small flood by organic layer in 10b layer. Also from the previous archaeological excavation in Hirate-cho site (Palyno survey, 2006), that there was on the ground surface environment, such as stagnant water temporary have been pointed out time said, that there was in terrain environment as well the point is estimated.

In this period, increase in *Quercus Cyclobalanopsis* at 7 to 11 layers indicate spread in evergreen forest around the Hirate-cho site. And, increasing in *Typha* as non-arboreal pollen, suggesting the wet ground surface environment same as the results in sedimentary facies.

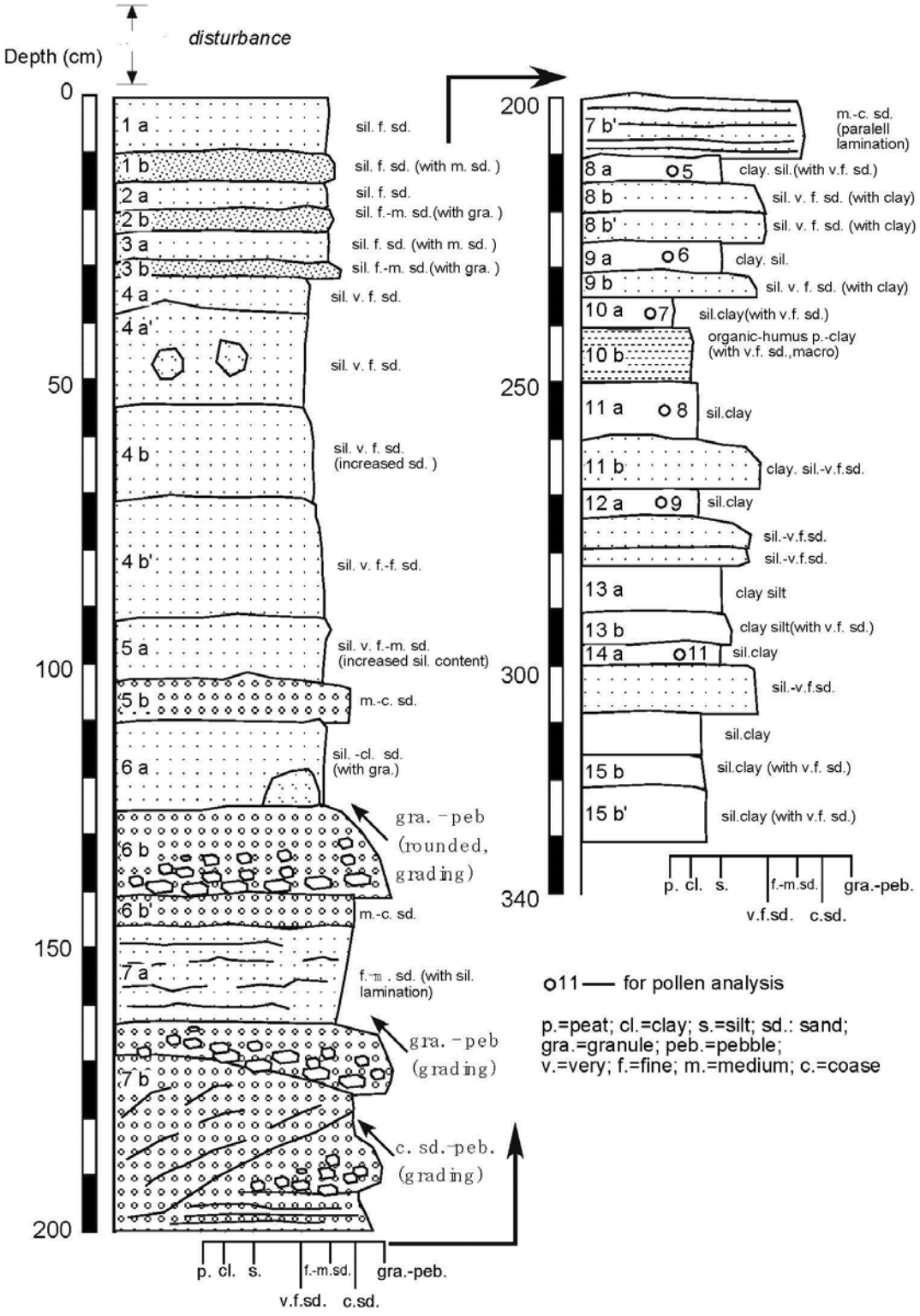

Figure 2. Sedimentary facies in Hirate-cho Site, Nobi plain, central Japan

Activation in fluvial activity (Kofun period; *ca.* AD 250 to 538): This period is characterized in activation in peripheral fluvial activity from the silty fine sand sediments are detected at 8 and 9 layers. Increase in *Q. Cyclobalanopsi*s from 8 and 9 layers pollen indicate the reconstruction of evergreen forest around the Hirate-cho site. In non arboreal pollen, temporary dry-up ground environments from the based in the emergence in Gramineae and *Artemisia* pollen. After that of this period, it is suggested that the point-bar and cross lamination sediments have detected at 6 and 7b layers. Fluvial sediments have including Kofun period archaeological remains (Fig. 3).

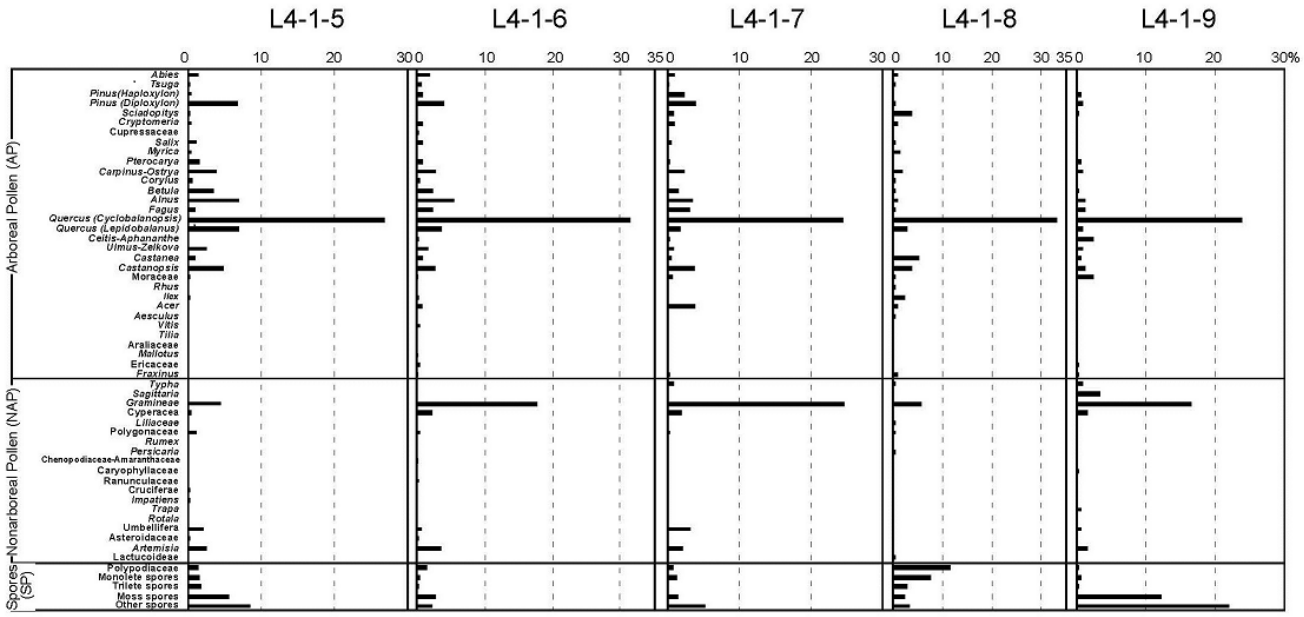

Figure 3. Pollen diagram from Hirate-cho Site, Nobi plain, central Japan

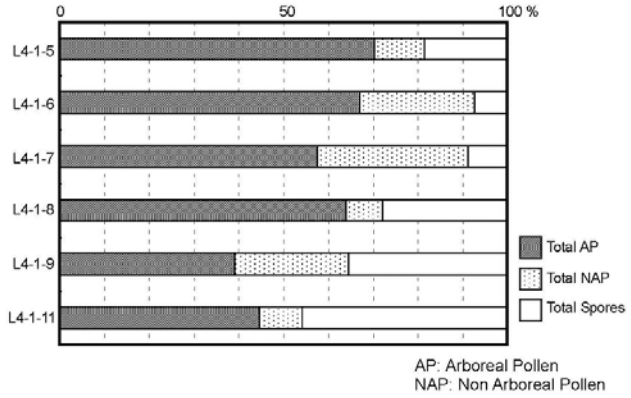

Figure 4. Pollen and Spore ratio diagram from Hirate-cho Site, Nobi plain, central Japan

Expansion of production areas (Medieval to Modern period; *ca.* 12th to 17th): This period is characterized in development in soilization than that before period without upper of 6 and 5b lalers including sand (flood) sediments. However, it can be interpreted as the soil of a layer has progressed by farming, because of a layer indicate the progress in soilization. Also from the fact that the sediment of block shape is mediated in part, it can be interpreted as human activities has been happened at the past e.g. in farming or making paddy fields (Fig. 4).

Especially, it is interpreted than that geo-environment in drastic change, because of dry up the land than that of period. The reason of above changes are reported in another areas (Takahashi, 2003).

Based on the characteristics of the sediments and the change of fossil pollen taxa, the landform evolution around the Hirate-cho site, in the Nobi plain, central Japan is considered as follows:

1. Yayoi period, is located in the environment lowland basis, there is no stagnant water permanent, but there is in an environment lowland basis floods temporary, such as those generated, peripheral vegetation covered in mainly evergreen forest.
2. Fluvial activity is active at the Kofun period, the ground surface was unstable and the landscape mainly of laurel was formed in the peripheral vegetation.
3. Ground drier is in progress since the Middle Ages, agricultural land development has been progressed.

Acknowledgement: This study is financially supported in part by the, Grant-in-Aid for Science Research (Project No. 21251005 led. by Dr. Kazuo Ando, Kyoto University and (Project No. 25370929 led. by Dr. Shinji MIYAMOTO, Okayama University of Science) from the Ministry of Education, Science, Sports, Culture and Technology of the Japanese Government.

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J. Agrofor. Environ. 11 (1 & 2): 133-137, 2017 ISSN 1995-6983

Indigenous methods on coping with natural disasters in selected areas of Bangladesh

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Abstract: The study focused the state of integration of local people's wisdom and their indigenous methods in mitigating disaster in selected areas of Bangladesh. It revealed that integration of local people's wisdom and indigenous methods with Comprehensive Disaster Management Program (CDMP) of the government is below the expected level. For coping with natural disaster, demand for external help is still dominant in people's mind set. Community Based Disaster Management (CBDM) approach is not getting adequate attention by people, government and NGOs. Official traditional top down Disaster Management (DM) approach of only rescue & relief was found dominant in the 16 sample Union Parishads in Bangladesh. There were limitations of cyclone shelter centers in respect of site, size, number, quality, water facility, sanitation, security, cattle shade, multipurpose use, ownership, maintenance and longevity. Caretaking and maintenance work arrangement for most of the cyclone shelter centers were found almost absent. For establishing CBDM with development dimension, local people's wisdom, indigenous methods, local community organizations and Local Government Institutions (LGIs) i.e. *Union Parishad* (UP) and *Upazila Parishad* (UZP) may be integrated with the DM process. As an alternative of constructing traditional low quality cyclone shelter centers of short longevity in future, government's subsidized multistoried cooperative housing estates similar to the cooperative housing society in urban areas of Bangladesh, may be constructed gradually for the middle class, poor and vulnerable people providing them long term bank loans at very low interest rate in coastal areas supported by the opportunity of long term loan repayment schedule at monthly thrift installments.
Key words: Indigenous methods, coping strategy, natural disasters, Bangladesh.

Introduction

A proverb says, "Farming without tree culture is Disaster refers to sudden or progressive natural events that seriously disrupt the functioning of a society causing human, material and environmental losses of such severity that the affected community has to respond by taking exceptional measures. The disruption, including essential services and means of livelihood, is on the scale that exceeds ability of the affected community to cope with using only its own resources. Natural disaster proneness of Bangladesh is due to frequent cyclone, storm surge, flood, tornado, drought and arsenic contamination. From 1797 to 1998, 67 major cyclone storms and storm surges have been reported to occur in Bangladesh (Alimullah, 2005; Anon. 2011).

Major Natural Disasters in Bangladesh during 1970-2009

Year	Disaster	Estimated Death of people
1970	Cyclone	470,000
1974	Flood	-
1988	Flood	2373
1988	Cyclone	5704
1989	Drought	800
1991	Cyclone	138,882
1996	Tornado	545
1997	Cyclone	550
1998	Flood	981
2004	Flood	747
2007	Flood	800
2007	Cyclone	3,406
2009	Cyclone	190

There is a paradigm shift in disaster management from traditional approach of rescue & relief towards developmental approach incorporating hazard mitigation and vulnerability reduction during warning phase, disaster phase and recovery phase. Thus Disaster Management (DM) refers to management of both risk and the consequences of disasters, includes both prevention and preparedness measures in anticipation of known hazards (pre-disaster) and long-term rehabilitation (post-disaster reconstruction). Government of Bangladesh (2003) has introduced Comprehensive Disaster Management Program (CDMP) in 2003 in partnership with DFID, UNDP and EU. According to the Yokohama Resolution in 1994, traditional top down approach of DM failed to address the specific local needs of vulnerable communities, ignore the potential of local capabilities and resources. But local community is the first to respond any disaster. Yokohama Resolution put thrust on Community Based Disaster Management (CBDM) approach. CBDM approach has been recognized internationally as an alternative way of DM. It involves Local Government Institutions (LGIs), Non-Government Organizations (NGOs) and Community Based Organization (CBOs) in DM. It seeks to develop and implement locally "appropriate" and locally "owned" strategy for DM (Yokohama Strategy and Plan of Action for a Safer World, 1994) .

In the above background the objective of the study was to find out the state of integration of local people's wisdom and local people's indigenous methods of coping with disaster to CDMP of the government at selected areas in Bangladesh.

Materials and Methods

Sixteen Focus Group Discussions (FGDs) were conducted with 16 sample *Union Parishads* (UPs) at respective UP Complexes. Out of 16 sample Unions, 10 were from natural disaster prone coastal districts and the rest 6 were from non-coastal districts. There were a total of 194 participants in the 16 FGDs. There were maximum 14 and minimum 8 participants in the FGDs. FGD participants were UP Chairmen, UP Members and UP Secretaries. The sample Unions were selected purposively from natural disaster prone coastal districts and non-coastal districts (Table 1).

Observations and Analysis:

Frequent natural disaster caused loss of lives, livelihoods and living conditions of disaster prone coastal areas. Department of Disaster Management (DDM) of the government of Bangladesh has District Disaster Management Committee (DDMC); *Upazila* Disaster Management Committee (UZDMC); Union Disaster Management Committee (UDMC); and 33,000 Volunteers covering 30 *Upazilas* of 11 disaster prone coastal districts. Yet the role of scattered indigenous measures was found

dominant considering quantity, quality and sustainability. Official disaster management efforts were very much inadequate considering quantity, quality and sustainability.

Table 1. Study Area and number of FGD participants

No. of FGD	Date of FGD	UP Offices of FGD	Upazila	District	No. of FGD participants
01	17.0712	Char Kolmi	Char Fashion	Bhola	10
02	18.07.12	Awazpur	Char Fashion	Bhola	08
03	24.07.12	Betagi Shankipur	Dashamina	Patuakhali	14
04	23.07.13	Dashamina Sadar	Dashamina	Patuakhali	12
05	01.08.12	Noon Khawa	Nageshwari	Kurigram	14
06	02.08.12	Hashnabad	Nageshwari	Kurigram	10
07	09.08.12	Magura	Kishoregonj	Nilphamari	13
08	08.08.12	Garagram	Kishoregonj	Nilphamari	08
09	05.08.12	nolpha	Raigonj	Shirajgonj	14
10	05.08.12	Dhangora	Raigonj	Shirajgonj	14
11	29.07.02	Veempur	Mohadevpur	Nowgaon	11
12	29.07.12	Uttargram	Mohadevpur	Nowgaon	14
13	16.07.12	Dorajhat	Bagharpara	Jessore	14
14	15.07.12	Dohakula	Bagharpara	Jessore	13
15	22.07.12	Firojpur	Meherpur Sadar	Meherpur	12
16	22.07.12	Kutubpur	Meherpur Sadar	Meherpur	13
-	-	-	-	Total	194

Results and Discussion

The deadliest cyclone in the history of Bangladesh caused deaths of 470,000 human being and innumerable cattle & poultry birds in 1970 in the coastal areas of Bhola, Putuakhali and Noakhali districts including six places of the sample area of this study. Cyclone also occurred at six places under this study area in 2012 causing several deaths of human lives and massive deaths of livestock and poultry. Those cyclones destroyed crops and many houses of the people. Tidal bore occurred at four places of the study area in 1988, 1996, 2007 and 2008 which destroyed crops. Floods in 1996, 1998 and 2012 caused damages of crops and houses of people at six places under the study area (Table 2).

Table 2. Natural Disasters occurred in the study area

Sl. No.	Name of disaster	Year of disaster	No. of place of disaster
1	Cyclone	1970, 2012	6
2	Tidal bore	1988, 1996, 2007, 2008	4
3	Flood	1996, 1988, 2012	6
-	-	Total	16

Due to the above mentioned disasters, most of the low cost houses were damaged at 100% places; crops were destroyed severely at 81% places; many cattle and poultry birds died or lost at 75% places; roads, bridges, culverts and ferry were affected or destroyed at 63% places; and many herbs, shrubs and trees were destroyed at 50% places. Other impacts of disaster were- saline water submerged crop lands; all fishes washed away from fish ponds; some people died and injured; people's living conditions disrupted; seed beds destroyed severely; affected electricity supply infrastructure; mango garden and banana plantation were affected severely; jute and sugarcane cultivation affected severely; school, college and other educational institutions affected; and diseases broke out (Table 3).

Table 3. Impact of disaster on living condition and production

Sl. No.	Impacts	No. of places of incidences	%
01	Most of the low cost houses were damaged	16	100
02	Crops were destroyed severely	13	81
03	Many cattle and poultry birds died and lost	12	75
04	Roads, bridges, culverts, and ferry were affected or demolished	10	63
05	Many herbs, shrubs and trees were destroyed	08	50
06	All fishes washed away from fish ponds	04	25
07	People died and winded	04	25
08	Electricity supply infrastructure were affected	04	25
09	Diseases broke out	03	19
10	Mango garden and banana plantation were affected severely	03	19
11	Jute and sugarcane cultivation were affected severely	03	19
12	School, college and other educational institutions were affected	03	19
13	Saline water submerged crop lands	02	13
14	People's living conditions were disrupted	02	13
15	Seed beds were destroyed severely	01	6
16	Betel leaf cultivation was affected severely	01	6

As indigenous measures for coping with disaster and damages mentioned above, people themselves reconstructed low cost houses by helping each other at 75% places; resumed agriculture by themselves at 50% places; planted trees at 44% places; resumed cattle and poultry rearing themselves at 38% places; repaired &

reconstructed roads, bridges and culverts at 31% places under this study areas through people's participation. People's other indigenous measures for coping with disaster were resumed fish culture in ponds; removed water logging to rescue some crops; took loan for housing, agriculture, fishery and cattle rearing; repaired barrage and cyclone shelter center through people's participation; mutually arranged medical treatment for each other; resumed betel leaf, banana and mango cultivation; provided post disaster food, shelter and some other goods to affected neighbors temporarily; repaired educational institutions by people's participation; and a few people migrated to other places as daily labor (Table 4).

Table 4. People's indigenous measures for coping with disaster

Sl. No.	Indigenous measures	No. of places of such measures	%
01	Reconstructed low cost houses by helping each other	12	75
02	Resumed agriculture by themselves	08	50
03	Planted trees	07	44
04	Resumed cattle and poultry rearing	06	38
05	Reconstructed and repaired roads, bridges and culverts	05	31
06	Took loan for housing, agriculture, fishery and cattle	04	25
07	Left houses for cyclone shelter centers and stayed there	03	19
08	Resumed fish culture in ponds	03	19
09	Mutually arranged medical treatment for each other	02	13
10	Provided post disaster shelter to affected neighbors temporarily	02	13
11	Provided food and other goods to affected neighbors	02	13
12	Removed water logging to rescue some crops	01	6
13	Repaired barrage by people's participation	01	6
14	Repaired cyclone shelter center by people's participation	01	6
15	Resumed betel leaf cultivation	01	6
16	Resumed mango gardening and banana cultivation	01	6
17	Repaired educational institutions by people's participation	01	6
18	Migrated to other places as daily labor	01	6

As measures taken by government organizations, local government institutions and NGOs for coping with disaster, food and some other materials were distributed among the victims as relief at 69% places of the affected areas. It was followed by distribution of cash money as financial grant to the victims at 44% places of the study areas. Corrugated iron sheets were distributed among the victims at 25% places of the study area as relief for housing. Such other official supports include distribution of seeds, fertilizers, credit, subsidy, clothing, utensils, VGD and VGF cards, latrine making materials and hand tube wells as relief to the victims at a few places of the study area (Table 5).

Table 5. Measures taken by government, local government and NGO for coping with disaster

Sl. No.	Measures	No. of places of such measures	%
01	Distributed food and other relief materials	11	69
02	Distributed taka as financial help	07	44
03	Distributed corrugated iron sheet as relief for housing	04	25
04	Interest free agricultural credit distribution	03	19
05	Provided medical treatment and medicine	03	19
06	Distribution of clothing as relief	03	19
07	Given seeds and fertilizer to farmers free of cost	02	13
08	Distributed utensils as relief	02	13
09	Latrine material and Hand Tube Well distribution	02	13
10	Resumed electricity supply	01	6
11	Provided agricultural subsidy	01	6
12	Provided medical treatment to cattle	01	6
13	Implemented rehabilitation measures	01	6
14	Plantation	01	6
15	Construction of barrage and sluice gate	01	6
16	Roads and bridges construction	01	6
17	VGD and VGF card distribution	01	6

Out of 16 sample Unions only five had cyclone shelter centers. The highest proportion of the respondents (63%) expressed their need for construction of cyclone shelter at each ward and house building materials as relief. Victims of 50% places of the study area demanded construction of barrage and sluice gate and re-excavating rivers and canals. Victims of 44% places demanded financial help as part of rehabilitation. Some other demands of the victims include training the people on coping with disaster and giving early signal; disbursing interest free loan to affected people; supplying emergency food and medical services to affected people after disaster (Table 6).

Majority of the respondents did not make any comment about the advantage of cyclone shelter centers. As

advantages of cyclone shelter center, only 25% respondents opined that people can take shelter during disaster, 19% said that cattle and poultry birds may be kept during disaster, a few others said that cyclone shelter centers may be used as schools and voting centers during election (Table 7).

Table 6. Needs of external help for coping with natural disaster

Sl. No.	Measures	No. of places proposed such measures	%
01	Constructing cyclone shelter center at each ward	10	63
02	Giving house building materials to affected people as relief	10	63
03	Constructing barrage and sluice gate and excavating rivers and canals	08	50
04	Giving financial help to affected people	07	44
05	Training people on coping with disaster and giving early signal	05	31
06	Disbursing interest free loan to affected people	04	25
07	Supplying emergency food and medical services to affected people after disaster	03	19
08	Employing disaster management workers with honorarium	02	13
09	Distributing adequate quantity of relief to affected to people	02	13
10	Improving road communication infrastructure	02	13
11	Constructing some high land for shelter of people and cattle	02	13
12	Ensuring adequate transport facility during disaster	02	13
13	Compensating crop loss	01	6
14	Giving subsidy to farmers of sugarcane, banana, mango, and betel leaf	01	6
15	Giving seeds and fertilizer free of cost	01	6
16	Distributing seedlings free of cost	01	6
17	Supply of tube well and latrine materials to people	01	6
18	Increasing allocation of resource for coping with disaster	01	6

Table 7. Advantages of cyclone shelter center

Sl. No.	Advantages	No. of places mentioned such advantages	%
01	People can take shelter during disaster	04	25
02	Cattle and poultry birds may be kept during disaster	03	19
03	School can be operated at cyclone shelter center	02	13
04	Cyclone shelter center may be used as Vote Center	01	6

Majority of the respondents did not make any comment about the problems associated with cyclone shelter centers. A few of them opined that only one cyclone shelter center per Union can accommodate only 30% people approximately; number of latrine was inadequate; there was drinking water shortage due to lack of tube well; lack of electricity connection; no room for keeping cattle and poultry birds; people had to take shelter at school buildings or other people's buildings during disaster due to lack of cyclone shelter center; stares of cyclone shelter centers were not suitable to be used by handicapped and old persons; quality of construction of cyclone shelter centers was poor; and cyclone shelter centers were not convenient to the people due to absence of maintenance work of cyclone shelter centers (Table 8).

Table 8. Problems associated with cyclone shelter center

Sl. No.	Problems associated	No. of places mentioned such advantages	%
01	Number of latrine is inadequate	02	13
02	Drinking water shortage due to lack of tube well	02	13
03	Lack of electricity connection	02	13
04	No room for keeping cattle and poultry birds	02	13
05	Only one cyclone shelter center per Union can accommodate only 30% people	01	6
06	People have to take shelter at school buildings or other people's buildings during disaster due to lack of cyclone shelter center	01	6
07	Stares of cyclone shelter centers are not suitable to be used by handicapped and old persons	01	6
08	Quality of construction of cyclone shelter centers was poor	01	6
09	Taking shelter at cyclone shelter center is not convenient to people due to absence of maintenance work of cyclone shelter centers	01	6

Frequent natural disaster caused loss of lives, livelihoods and living conditions of disaster prone coastal areas. Department of Disaster Management (DDM) of the government of Bangladesh has District Disaster Management Committee (DDMC); *Upazila* Disaster Management Committee (UZDMC); Union Disaster Management Committee (UDMC); and 33,000 Volunteers covering 30 *Upazilas* of 11 disaster prone coastal districts. Yet the role of scattered indigenous measures was found dominant considering quantity, quality and sustainability.

Official disaster management efforts were very much inadequate considering quantity, quality and sustainability. People's remarkable concern was how to safe their physical and financial wealth, livestock, poultry birds, pond fishes and standing crops at field. The rich people were found to help the poorer neighbors with shelter and food remarkably during natural disaster. During practical visits to several cyclone shelter centers, the researcher observed the limitations of cyclone shelter centers in respect of site, size, number, quality, water facility, sanitation, security, cattle shade, multipurpose use, ownership, maintenance and longevity. Caretaking and maintenance works arrangement for most of the cyclone shelter centers were found almost absent.

Traditional top down DM approach of only rescue & relief is still dominant in the study areas. Such supports are inadequate against the huge demand. Development oriented sustainable efforts for coping with disaster is still missing. Integration of local people's wisdom and indigenous methods with CDMP of the government is below the expected level. For coping with natural disaster, demand for external help is still dominant in people's mind set. CBDM approach is not getting adequate attention by people, government and NGOs.

For establishing CBDM with development dimension, local people's wisdom, indigenous methods, local community organizations and Local Government Institutions (UP and UZP) may be integrated with the DM process. As an alternative of constructing traditional low quality cyclone shelter centers of short longevity, government's subsidized multistoried cooperative housing estates similar to the cooperative housing society in urban areas of Bangladesh, may be constructed gradually for the middle class, poor and vulnerable people providing them long term bank loans at very low interest rate in coastal areas supported by the opportunity of long term loan repayment schedule at monthly thrift installments (Dasgupta, *et al*., 2011). Earthen platforms (*matir killa*) may be made for pre-disaster and during disaster shelter of the poultry birds and cattle of people in the similar way adjacent to the recommended cooperative housing. A law may be enacted so that the rich of the coastal areas become bound to construct own multistoried houses for themselves and as shelters for some neighbors during disaster. If necessary the government may provide the rich with low cost bank loans. International and national development partners may support the recommended cooperative housing programs for the poor and middle class people.

Acknowledgement: The author hereby acknowledges the cordial cooperation of 16 sample *Union Parishads* in organizing 16 FGDs and to Research Investigators, Supervisors and Tabulators of Bangladesh Academy for Rural Development (BARD), Comilla for their respective supports in conducting this study.

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J. Agrofor. Environ. 11 (1 & 2): 139-142, 2017 ISSN 1995-6983

Swidden farming in rain-green forests of mainland Southeast Asia

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Abstract: In terms of the period of crop planting and fallowing, three types of swidden farming have been noted- (1) short-term cultivation with long-term fallow, (2) short-term cultivation with short-term fallow, and (3) long-term cultivation followed by migration and abandonment. The first category is the most common type of swidden farming in the continental areas of Southeast Asia, in which upland rice is cropped for one year followed by fallowing the field for nearly ten years. Since upland rice seed is sown by maintaining a certain distance between the seeds using dibbling sticks, the surface of the soil is not disturbed. Further, the secondary forest is fully restored during the fallow period thanks to pioneer tree species and the regeneration of stumps through the sprouting of new branches. The second category is the early stage of the paddy field cultivation process or complementary swidden farming. Many of these fallow fields are bamboo forests. The third category is the swidden farming of the Mong, who live in the montane forest above 1,000m altitude. As commonly observed in Myanmar, Thailand and Laos, swidden farming in the monsoon zone ends with a single year of cropping. Here swidden farming in the rain-green forest of Karen village in the Bago Mountains and a Khmu village in northern Laos is reviewed.
Key words: Swidden farming, rain-green forests, Southeast Asia, short-term cultivation, long-term fallow.

Rain green forest and Laurel forest

The greater part of continental Southeast Asia has a monsoon climate with a distinct dry season, and there is a wide distribution of monsoon forest, also known as "tropical seasonal forest." Compared with tropical rainforest, tree heights are lower, the layered structure is simpler, and leaves fall in the dry season, though only for a short period of time. Tropical seasonal forests are classified into three types according to the degree of dryness; (1) evergreen seasonal forest, (2) semi-deciduous seasonal forest, and (3) deciduous seasonal forest. There are no gigantic trees in an evergreen seasonal forest. Some tall trees lose their leaves in the semi-deciduous seasonal forest, as do almost all trees in deciduous seasonal forest. If the area is drier than this it becomes savanna. Aside from such seasonality in rainfall determined by latitude, there are also changes in rainfall that depend on altitude. High altitude areas have montane rainfall. Such an area develops a so-called "moss forest," i.e., an evergreen montane forest composed of oak and laurel trees of Fagaceae and Lauraceae. These trees are covered by moss.
In the continental areas of Southeast Asia, the evergreen forest in upstream mountain land connects with laurel forests, while the evergreen forest in downstream lowland areas connects with tropical rain forests. Between them spread the monsoon forests, where leaves fall during the dry season and the scenery turns green all at once with the arrival of the rainy season. In May, the southwest monsoon brings rain from the Indian Ocean, which very rapidly turns the landscape in these areas to green. Because of the vivid impression this change creates on people, monsoon forest is also called "rain-green forest".
The "Thai cultural sphere" spreads from this monsoon forest zone to the laurel forest zone. This cultural sphere extends to six countries-Vietnam, Laos, Thailand, Myanmar, India, and China straddling the great rivers that flow down from the Tibetan Plateau; the Mekong, the Salween, and the Brahmaputra, as well as their watersheds. In this region, the altitude of approximately 1,000m divides the landscape like a borderline, with mixed deciduous forest and dry dipterocarp forest spreading in the lower part, and evergreen montane forest in the upper part. The domain of the Thai cultural sphere overlaps with the transitional zone of rain-green forests and laurel forests.
In the continental areas of Southeast Asia, the most common type of swidden farming has been the one-year crop of upland rice in the rain-green forest zone. On the other hand, various types of crop rotation methods are observed in swidden farming performed in the laurel forest zone. Although the relations between the ethnic groups and their livelihood activities or their ways of making use of the environment are not fixed in any way, let us take a look at the general picture as it has been in the northern part of Myanmar, Thailand and Laos up to now.
In Laos, people are classified into three categories; *Lao Sung* (highland Lao), *Lao Theung* (midland Lao), and *Lao Lum* (lowland Lao). Although the actual habitation areas are intricately interwoven, simply stated, the highland Lao sustain their livelihoods by swidden farming (poppy farming in the past) in the evergreen montane forest zone, the hillside Lao by swidden cultivation of upland rice and the gathering of forest products in the mixed deciduous forest zone, and the lowland Lao by lowland rice cultivation in paddy fields in the flatlands.
As in Laos, the separation of mountain dweller habitation primarily by altitude was also clearly observed in northern Thailand until the 1960s. There have been different types of swidden farming, including the poppy fields of the Mong in evergreen montane forest, the swidden farming of the Karen, ranging from evergreen montane forest to mixed deciduous forest, and complementary swidden farming by lowland Thais. In terms of the period of crop planting and fallowing, three types of swidden farming have been noted; (1) short-term cultivation with long-term fallow, (2) short-term cultivation with short-term fallow, and (3) long-term cultivation followed by migration and abandonment.
The first category is the most common type of swidden farming in the continental areas of Southeast Asia, in which upland rice is cropped for one year followed by fallowing the field for nearly ten years. Since upland rice seed is sown by maintaining a certain distance between the seeds using dibbling sticks, the surface of the soil is not disturbed. Further, the secondary forest is fully restored during the fallow period thanks to pioneer tree species and

the regeneration of stumps through the sprouting of new branches. The second category is the early stage of the paddy field cultivation process or complementary swidden farming. Many of these fallow fields are bamboo forests. The third category is the swidden farming of the Mong, who live in the montane forest above 1,000m altitude. Until recent years, the Mong grew poppies (*Papaver somniferum)* and maize for a long period in one place, followed by abandonment and the clearing of new swiddens elsewhere. The Mong, who are highland dwellers, lived on maize originating from the new continent, and cultivating poppies. It would be reasonable to consider that this type of long-term cultivation is a technique of permanent cultivation originally introduced from China.

There are three types of agriculture in the mountain areas of northern Myanmar; monsoon *taungya*, grassland *taungya*, and irrigated hill terraces. A monsoon *taungya* is cultivated for one year only, and then fallowed for 12 to 15 years. In a grassland *taungya*, after practicing a crop rotation of maize, buckwheat, millet, wheat and barley, the land becomes grassland fallow.

Leach has described this as follows; 'When *taungya* and hill terraces are both cultivated by the same community, as is often the case, the people concerned seem usually to regard *taungya* cultivation as the more rewarding. On the other hand, since terraces can be cultivated year after year with little or no fallow period, relatively dense local aggregates of population are possible. Hill terraces are thus usually found associated with unusually large communities on permanent sites. The real advantage of hill terrace systems seems to be military and political rather than economic.' (Leach 1954) This is a notable point in the comparison of swidden fields and paddy fields, and in my opinion is a viewpoint that leads to the notion of agricultural intensification which argues that intensification is achieved at the cost of labor productivity.

As commonly observed in above-mentioned northern areas of Myanmar, Thailand and Laos, swidden farming in the monsoon zone ends with a single year of cropping. All activities, including site selection, clearing, burning, sowing, weeding, control of agricultural damage by wild animals, and harvest are performed in one year. These peoples have repeated the process of "select, cut, burn, sow, raise, protect and reap" year after year, with the arrival of the dry and rainy seasons.

Karen swidden farming in the Bago mountains

In the Bago Mountains, located between Mandalay and Yangon in Myanmar, the Karen people practice swidden farming in mixed deciduous forests. Let us take a look at the content of their activities.

Site selection: When the dry season comes, a field is selected for burning. They do not perform swidden farming within one kilometer of the area surrounding the village since this area contains water conservation forest and areas for collecting fuel wood. The people choose a "cold" area with black soil, avoiding ridges because the soil there is "hot." The people say places where Thai-wa bamboo (*Bambusa tulda*) grows are suitable for swidden farming because these places are relatively flat and the soil is clayish.

When they find a place that seems suitable, they take a handful of soil back to their house, put it under their pillow and sleep. If they have a good dream, the place is satisfactory, and if they see a bad sign in a dream, they will seek another candidate site.

"Evil spirit, please go away. We are going to work in this place for food, to support my wife and children. May no mischief happen here. We will work to the last." These are the Karen words offered at the ritual of *Ta mawa hku*.

Cut and clearing: In December, the mountain area becomes much colder. The large leaves of teak trees become wet with the night dew, which drops like rain. The drops hit the parched leaves on the forest floor making a thudding sound. Clearing begins in the cold season, around mid-January. Clearing is a man's work. The men cut trees starting from the lower part of the slope, using a woodman's hatchet. Chataung-wa bamboo (*Bambusa polymorpha*) and Tin-wa bamboo (*Cephalostachyum pergracile*) are clumping bamboos whose multiple culms from sypodial rhizome stand as if bundled together. The Karen people cut them from the outside. They cut big trees at about two meters above the ground, not at ground level. They prop the cut bamboo stems against the tree like a ladder and cut the tree using the bamboo to stand on.

A newly-cleared swidden field will be left as it is to dry. Daytime temperatures become hotter after the Chinese New Year in February, and the hot season arrives in March. Generally in February the Karen make firebreaks of three meters in width around cleared fields in order to prevent the forest fires from invading the field. The people sweep away fallen leaves and sticks so that the forest fire cannot spread to the field from outside.

Burning of slush: The hottest season in the year is around the time of the Water Festival in April. The fields are burned at this time of the year. Burning starts from around 1 p.m., the hottest time of the day. The result of the burning greatly affects the crop. Two or three days after the burning, the people gather the residual woods and conduct a second burn, and then begin to build a temporary field hut in the field.

Seed sowing: In May, a southwest monsoon wind brings rain and the parched land turns to green all at once. This is the period of the year when you can get a real sense of the meaning of the name "rain-green forest." With the arrival of the rainy season, the Karen strike holes in the soil with a dibbling stick and drop seeds into the holes. The dibbling stick is made of bamboo and has holes bored in it so that it makes a popping sound when the people strike the ground with it. It is a digging stick with a clapper.

The Karen raise three varieties of upland rice; non-glutinous early maturing variety, non-glutinous late maturing variety and glutinous medium maturing variety. Other than sesame, chili pepper and cotton, their main cash crops, they also grow millet, sorghum, maize, Job's tears, sugarcane, common beans, pigeon peas, cassava, konjac, cucumbers, melons, pumpkins, eggplants, okra, tomatoes, *Indigofera* spp., hibiscus, tobacco, bananas, as well as flowering plants such as feather cockscomb (*Celosia argentea*) for ornamental and ceremonial use.

Raise weeding: Rains not only raise crops, but also grow thick weeds. Weeding begins just after sowing, and is carried out three times up to the end of September. Weeding is a hard work.

Protect agricultural damage caused by wild animals: The Karen make a fence around the swidden field by September to prevent wild boars that eat upland rice and barking deer that eat chili peppers from entering the field. The swidden fields are surrounded with the bark of the Shaw-ni *(Sterculia villosa)*.

Clappers are used to scare deer away. The rope for the clapper is also made from Shaw-ni *(Sterculia villosa, S. versicolor)*.

Harvesting: The harvest of the early maturing rice begins in November, and the harvest of the late maturing rice is completed in December. The grain is threshed at the field hut and stored in a rice granary. Feather cockscomb flowers bloom in the swidden fields around the time of the rice harvest, turning them into flower gardens.

Fallowing: Shortly after the fallow period has started, *Chromolaena odoratum* and *Thysanolaena maxima* begin to grow. The fallow land is covered by these grass in the first one or two years. Following these grass, bamboo species recover. Species such as Chataung-wa bamboo and Thai-wa bamboo are usually seen in fallow land. When you walk around in this kind of bamboo forest, all around the area you will see small piles of soil made by digging the surface. These are the work of the lesser bamboo rat (*Cannomys badius*), called *bwi* in Karen and *pwi* in Burmese. The soil they have dug out to make their nesting holes is piled up by the entrances. The lesser bamboo rat digs underground tunnels from the entrance and scrapes out soil at regular intervals. In this way, they breed in the nest holes in the ground, eating bamboo roots and bamboo shoots. There are also traces of digging by wild boars on the ground. The ground in the fallow areas, especially those of young fallows, looks as if it has been cultivated. The cultivation power of animals plays a significant role in the recovery of fertility in fallow land. Unlike the Japanese word *shinkan* ("the hushed silence of the forest"), fallow forest is in fact quite a lively world where animals are very active.

Regeneration of new branches begins from the pollards of trees such as *Xylia xylocarpa* (Burmese iron wood) which were cut well above the ground when clearing the field. The height of these trees exceeds that of bamboo after about ten years have passed after cutting. The biomass of trees recovers to a level roughly the same as that of bamboo. The secondary forest, where bamboo and trees are mixed in this way, is a suitable area for swidden farming because clearing is easy and the biomass burns well.

The transition of the vegetation that covers the land after swidden farming, from grass, to bamboo and then to trees, is the process of secondary succession. Swidden farming involves the troublesome work of weeding. Swidden fields require weeding at least three times in the first year. In the second year, as much as three times the amount of weeds will grow compared to first year. It therefore saves trouble and is more rational to allow secondary succession proceed and wait for the weeds to be defeated by the bamboo and trees covering the ground and darkening the forest floor instead of fighting a losing battle against weed infestation.

Khmu swidden farming of the northern Laos

The Khmu people produce upland rice in swidden fields below an altitude of around 1,000m. After a single crop in the first year, the field is fallowed for six or more years. They produce upland rice for self-consumption and earn cash by producing and gathering forest products.

In the swidden fields of the Khmu people of northern Laos, Siam benzoin *(Styrax tonkinensis)*, a pioneer species, is the dominant species in fallow forests. Khmu people collect benzoin resin in the seventh and eighth year of fallowing, following which they clear the forest and carry out swidden farming in the ninth year.

Siam benzoin, a tree found in the mountain areas of northwestern Vietnam and northern Laos, provides benzoin resin, a raw material for perfumes and medicine. In particular, northern Laos has been known as a production area of Siamese benzoin since old times. Siam benzoin is a fast-growing, indigenous species and becomes the dominant species especially in a fallow forest after swidden farming. Benzoin resin has been produced in fallow land after swidden fields have been used to produce rice.

Here I would like to present the case of a village in Louang Phabang Province in northern Laos. Many of the secondary forests surrounding the village are fallow swidden fields consisting of Siam benzoin trees. The people clear the fields to be burned from the end of December to February, and burn the fields from the end of March to April. This burning breaks the dormancy of Siam benzoin seeds that have fallen to the ground during the previous autumn. When May comes, bringing the rain, the people sow upland rice seeds keeping a certain space between them. They also grow cassava, sesame, chili pepper, Job's tears, rattan, feather cockscomb and other plants in the swidden fields. At the time when the upland rice grows to around 30cm, Siam benzoin seedlings of about 5cm in height can be observed almost everywhere around the swidden field. Weeding is carried out three times. At the same time, the people carefully keep the seedlings. By the time the upland rice is harvested, the Siam benzoins have grown to about head height. The extraction of benzoin resin is conducted in the seventh and eighth years. The field is then cleared and swidden farming is carried out again in the ninth year.

Burning of the field facilitates germination, and Siam benzoins will grow as a pioneer species in fallow fields. They are felled after their resin is collected, and a new cycle of swidden farming begins. Here the combination of Siam benzoins and swidden farming is advantageous for two reasons; (1) the characteristics of the trees as a pioneer species, i.e., Siam benzoins are light demanding species, and their germination is facilitated by burning, and (2) regeneration is required because the resin can be extracted only for two years.

In northern Laos, cardamom and rattan as well as benzoin resin are gathered in the fallow lands after swidden farming. Lac and eaglewood are also produced on fallow

lands. The fields greatly contribute to the livelihood of swidden farmers as a "productive fallow."

Strength of Water and Fire

In the rainy season, green paddy fields can be seen in intermount basins. The rainy season from May until around October is the season for farm work. From November until around April is the dry season when the people carry out the clearing and burning of swidden fields. In the continental areas of Southeast Asia, paddy farming and swidden farming have been practiced to the rhythm of the monsoon climate in which rainy and dry seasons are repeated alternately. The "Thais," who cultivate paddy fields, may sometimes perform complementary swidden farming in side valleys and the areas between mountain foothills and arable flat land. On the other hand, mountain dwellers sometimes cultivate paddy fields. In this sense, "Thais" and mountain dwellers form a continuum.

The Chinese character "畑" is a *kanji* unique to Japan, composed of "火" (fire) and "田" (field). While a paddy field (*suiden*, "水田") is called *ata* ("田"), an upland field is made by burning away the vegetation on the ground and is called a *hatake* ("畑"). It is said that in ancient China, an area of land burned in order to carry out hunting by surrounding an area of forest was called "火田," which later came to mean a swidden field.

In order to create the conditions necessary for crops to grow, people change the environment by borrowing the strength of water in paddy fields, or fire in upland fields.

In swidden farming, before cultivating upland rice, people burn the field to restore the conditions to those of an early stage of succession. During the fallow period, the recovery of secondary forest is left to the natural process of succession. When the forest has recovered, the fields are cleared and burnt again, and upland rice will be grown. This process of succession, taking ten or more years for each cycle, has been repeated in swidden farming.

A paddy field maintains the conditions of the early stage of hydrarch succession by inundation. In this way, the conditions of an early stage of succession are restored by the strength of fire in the case of swidden farming, and by water in the case of a paddy field.

There are four major types of succession process; (1) xeric succession, (2) hydrarch succession, (3) psammophytic succession and (4) halophytic succession. Swidden farming falls into the first category, and paddy cultivation into the second category.

Swidden farming repeats the process of disturbance and succession in which forests are burned and then recover on the land formerly cultivated. Therefore, the forests where swidden farming is practiced are, unlike the case of monoculture plantation, not uniform, forming an uneven patchwork of swidden fields, young fallow land, old fallow land and deep forests. This uneven patchwork provides diverse habitats for plants and animals, and this diversity has brought about the possibilities for various products.

Forest Products from Fallow Land

People of the continental areas of Southeast Asia have been connected with the external world through the trade in forest products. These products have been gathered to port cities located along the rivers.

For example, among the exports of the ancient kingdom of Lan Xang, particularly important were gold, lac and benzoin resin. These forest products were transported across mountain passes carried on the backs of people, horses and oxen, shipped down rivers to port cities such as Ayutthaya, and then exported to Europe and beyond from the Coromandel Coast on the far side of the Indian Ocean. The products conserved well, and were therefore able to travel long distances, were easy to transport, and were lucrative. For centuries, people in northern Laos have lived self-sufficient lives practicing swidden farming, supplemented by cash income from forest products.

The mountain area of continental Southeast Asia that leads to Yunnan and Assam is also the origin of tea plants. In northern Thailand, northern Laos and the Shan State of Myanmar, people produce chewing tea, known as *miang* in Thai, and "lahpet" in Myanmarese. The people chew the tea leaves, which are fermented after steaming the raw leaves. In *miang* tea gardens, the tea plants are planted under the tall shade trees of the mountain forest. In these tea gardens, the gathering of firewood for steaming tea leaves was combined with grazing forest for the draft oxen used for shipping the chewing tea. Here the grazing inside the forests has prevented wildfires from invading the field areas in the dry season.

Kingdon Ward (1960), who conducted field study in the Mishmi Hills of Assam, in search of wild species, has written as follows; '*Camellia sinensis* is a plant of the foothills, not of the plains. Is it not significant how its cultivation, even its very existence, seems to cling around places where the much-travelled Tai race is, or has been or could have been? The long road of their migrations is still bordered with tea-bushes. Will anyone claim that this is coincidence?' Almost all of these tea gardens are developed in former swidden fields. We can consider that the planting of tea and eaglewood imitates the last stage of secondary succession. The Thai cultural sphere, spreading from rain-green forests to the laurel forest zone, is a world where mountain ranges are decorated with a patchwork of disturbances and successions of swidden fields that produce various forest products.

Note: This paper is a revised version of Takeda, S. (2011) Swidden Farming and Monsoon Forests of Mainland Southeast Asia: A Patchwork of Disturbance and Succession. Journal of Agroforestry and Environment 5.

Acknowledgements: This research was financially supported by Grants-in-Aid of the Ministry of Education, Culture, Sports, Science and Technology (21255003) and the Environment Research and Technology Development Fund (E1002) of the Ministry of the Environment, Japan.

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J. Agrofor. Environ. 11 (1 & 2): 143-147, 2017 ISSN 1995-6983

Internal labour migration study in the dry zone, Shan state and the southeast of Myanmar

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Abstract: This study focuses on internal labor migration and its impact on livelihood, socio-political atmosphere in the dry zone, Shan state and the Southeast of Myanmer. Internal labor migration is an important livelihood strategy amongst the rural populations to increase their income and livelihood security. The major reason for internal migration is the lack of year-round and sufficient income opportunities in the destination locaitions. Moreover, the wage difference, the lack of availability of off-farm work and seasonallity of agriculture sactor are the cause of internal migration. Among the internal migration stream, intra-state migration is very high in Shan and Mon state. In the dry zone both intra- and inter state migration is popular.
Key words: Internal labour migration, dry zone, Shan state, southeast Myanmar.

Introduction

Migration of people for labour is gaining importance globally, as the remittances migrants send home to their families account for a significant share of the overall household income, particularly so for poor households. In 2013, a total of 232 million people migrated from their places of origin globally, a 33% increase from 2000 (UN, 2013). The remittances sent home by international migrant workers from developing countries are estimated to be 404 billion USD in 2013 (World Bank, 2014). Though there is data available for international migration, statistics and information on internal migration is very limited. However, it is well known that migration within the country is one of the most common coping strategies adopted by poor households to stabilize their livelihoods and to adapt to climate, social, political and economic changes. Internal migration generally refers to mobility of people from their origin areas (departure area) to a new place (destination area) for work purpose but remaining in-country.

Myanmar is the second largest country in the Southeast Asia and is rich in natural resources including arable land, forests, minerals, natural gas, and fresh water and marine resources. Myanmar's population is estimated at over 55 million and is largely rural, still reliant on primarily agrarian economy, contributing about 36 % to the gross domestic product of the country and accounting for 60-70 % employment (http://www.themimu.info/country-overview. Long-standing conflicts and decades of martial law and rule have setback the development of this once prosperous Southeast Asian country. After 30 years, a population census was carried out in 2014. The little information gathered through certain surveys (such as Fertility and Reproductive Health Survey) reveal that internal migration in Myanmar is very high and that the predominant migration pattern is rural-rural rather than rural-urban (Nyi, 2013).

The study covers different internal migration modalities in Myanmar, including: (i) Internal labour migration profiles (who migrates, how and where to, sectors of employment, skills on demand) and patterns (permanent, temporary, seasonal/circular) in selected sample targeted areas, (ii) Mapping of stake holders per institutions involved in the migration cycle and legal and institutional frameworks existing in migration management, and (iii) Major reasons for migration and most significant impacts on the livelihoods of households and communities in the origin and destination areas.

Materials and Methods

Study sites: The study focuses on selected sample townships in the Dry Zone, Shan State and Southeast Myanmar. This is the triangle where HELVETAS is currently working and foresees future projects. Some general population features of the States/Region selected for the study are given in Table1.

Table 1. Some general features of the selected study states/regions

State/Region	Population	% of total population	Urban (%)	Population density	Household size
Magway	3,912,711	7.6	15.1	206	4.4
Nay Pyi Taw*	1,158,367	2.3	32.5	164	4.1
Mandalay*	6,145,588	12	34.8	87	4.1
Mon	2,050,282	4	27.8	167	4.6
Shan	5,815,384	11.3	24	38	4.7

Source: DoP, 2014

In each Region/State, 1-2 townships were chosen for the field visits. In each field site, apart from collecting general internal migration data and patterns, some specific information was collected from identified sectors where involvement of internal migrants is high. Selected States/Region and townships with relevant labour sector for the field visit are given in Table 2.

Methodology: In order to first value and secondly complement existing and planned migration related studies in Myanmar, a comprehensive desk review and preliminary exchanges with different development and research agents involved with migration were carried out. This also aimed to help compare and verify findings to date wherever possible. However, there was very limited number of studies/secondary information available for such comparisons. Two days of introductory interviews helped in forming some general impressions as well as identifying additional organizations and persons to contact in the field visit.

Table 2. Study States/Region and townships

State/Region	Townships	Sectors
Mon State	Mawlamyine, Mudon,Kyaikmaraw	Rubber plantation, fisheries
Magway	Magway, Minhla	Oil seeds
Nay Pyi Taw	ZayYarThiRi, Nay Pyi Taw	Restaurant, construction & farm households
Mandalay	Mandalay, Patheingyi	Paddy, dairy, off farm work
Shan State	Pin Laung	Tea plantation

The field visits involved rapid and intensive two-week expedition to the selected study sites, where a number of various stakeholders were interviewed. These included migrants in origin and destination areas, including migrants' families in origin areas, labour agents (who facilitate migration process), township officials, and private sector employing migrants, farmers, civil society and other key informants. As there was no quantitative data collection and as the study is based on the "expert opinion", the findings of the study are of qualitative value; including several case studies. However, in order to ensure consistency of the findings, same information was collected by interviewing different stakeholders involved in a given sector. Interaction with various stakeholders was facilitated by one-to-one interview, discussion in small groups of varied stakeholders, or focus group discussion with the groups of migrant labourers. The study team is aware of several quantitative studies with direct or indirect information on internal migration being planned by organizations such as World Bank, ILO migration mapping, ILO labour force survey etc. These planned surveys may fill existing gaps in the data on migration in Myanmar. It is hoped that the present report will be useful to planned research to provide preliminary ideas on internal migration patterns and impacts.

Results and Discussion

Reasons and Gender of Migration

Reasons for migration: The most commonly cited reason for migration is income generation, mostly through employment – year-round employment opportunity, better paying employment opportunity, and employment with possibility of gaining additional skills. From the Dry Zone, most migrants reported lack of sufficient employment in the local community as the major reason for migration.

Landless/near-landless households find it easier and preferable to migrate with their entire family or leaving just 1-2 members behind to look after the farm and livestock back home. Such migrants are mostly temporary or permanent, depending on opportunities and family. For them, migration is a livelihood and survival strategy to reduce the number of mouths to be fed. Households with some land holding are mostly involved in seasonal labour migration with only 1-2 members working in the destination, while the remaining household members stay back. Depending on the labour needs on the family farm, these migrants also usually visit their native village during the peak season.

Still a slightly better-off rural families with access to more and secured land are involved in internal migration to non-farm better paid formal sectors such as working in the private sector, public jobs, non-government organizations etc. Migration is no more a survival strategy, but an opportunity to further skills development and better career prospects. The most households in Patheingyi Township in Mandalay region, with huge land holdings are employed in salaried jobs in Mandalay city, thus creating demand for migrant labour for their paddy fields.

During the field visits, various other reasons for migration were noted. Development interventions and infrastructure construction has also resulted in migration, which could be both internal and international. For example, in Gokye village, Saytoketaya township, Magway region, due to construction of a dam, the entire village had to be relocated. As a direct result of this relocation, 70 persons from the village of 87 households migrated to Thailand and many more migrated internally.

Gender in migration: In internal migration, both men and women migrate, while international migration is mostly male dominated. Most internal seasonal male migrants are either single or, when married, the distance to the origin village is not very huge, so that they can regularly visit home. Similarly, most female seasonal migrants are single and migrate to nearby areas or as dependent of the spouse or family members. The sector of work has a clear gender division with women being higher demanded in tea plantations and other agriculture work, garment factories and as domestic help; whereas men are much preferred in rubber plantations (as tappers), mines, and the construction sector. The pay in these sectors certainly differs, but it is not clear if there is gender discrimination in the payment.

Findings by study areas and sectors

Southeast (Mon State): In Mon State, most internal seasonal migrants were from within Mon State, while migrants from outside are mostly year-round temporary (with or without family) in nature. Most of the migrants in the study sites had temporary settlements – Mawlamyine (65%), Mudon (70%) and Kyaikmaraw (73%). The migration pattern depends on the sector which, in turn, depends on the origin of the migrant workers. While migrants from the Delta region are mostly involved in fisheries and rubber plantation, migrants from the Dry Zone are involved in construction work, brick factory, and to some extent on rubber plantation. Some migrants have also found work in various factories in the area such as water purification plants, chilli factory, tyre factory etc. Work in brick factories is seasonal in nature, lasting for 4 months from November to February. Work in construction, factories, rubber plantations is more permanent in nature. However, even migrant workers in brick factories might not necessarily be seasonal as they might stay in the area and find work elsewhere during the off-season – road construction, paddy fields etc. High demand is reported of female migrant workers from the Delta region in the Karaoke Bars, popularly known as "KTV".The wages in various sectors in Mon state were more attractive than in

other regions for labour. A major constraint is to retain the migrant labour in rubber farm. In rubber sector, with the fluctuating prices of rubber, migrant labours are losing attraction to work in the sector. In addition, the seasonality of the rubber tapping limits the earning potential of migrant workers in this sector. Thus, removing these two barriers would be important to overcome the labour shortage problem faced by the rubber sector as well as to improve the livelihoods of the rubber sector migrant workers.

Fish sector also attracts a lot of migrant labour but mostly from the Delta region, Yangon and Mon State. Migrant workers from Yangon and Mon state work in Northern Mon state (e.g. Paungtownship), however, those from the Delta region work in Southern Mon (e.g. Ye Township). This is because of the similarity in fishing technologies used at the origin and destination for the migrant labourers, thus making work more familiar. Kyaikto Township is a major source area for migrant workers in the fishery sector. Since decreasing fish catches in the last 8 years, fishing is continued throughout the year, including the rainy season. Therefore, most migrants come with family and are permanent or long-term settlers. However, some of the Mon State internal migrants are individual migrants with their families remaining back home.

Shan State: Shan State attracts a lot of migrants from the Dry Zone to work in mines, tea plantations, sugarcane farms, etc. Labour force from Shan State itself is attracted to international migration to China, Thailand and Malaysia. This also creates an additional demand for migrant labour to replace the lost labour in the various on- and off-farm sectors in Shan State. As the Shan language is very similar to the Thai language, Thailand is a preferred destination for migrants from South and East Shan. It is reported that half of the youth population from Pin LaungTownship in South Shan has migrated to Thailand to work in construction, factories, and – for females – as domestic workers. On the other hand, due to closer geographical proximity and high demand and wages in China, labour from North Shan migrates in large numbers to China. It is reported that about 60 persons of the age group of 18-30 years leave daily from Namhsan Township to work in China; similar trend are also reported in Mongton Township.

Hence, Shan State is both a destination and transit place for the migrants from the Dry Zone. Dry Zone migrants find work in the tea and sugarcane plantations but they also use it as a transit point for migrating to China and Thailand. Most migration from Shan State is either intra-State or international/cross-border. Intra-State migration is made from one village to another to work as seasonal labour migrants or to the urban centres. Seasonal migration to neighbouring villages to work in tea and other crops is reported in the townships of Pin Luang, Pindaya, and Pangwuar. Migration to urban and peri-urban centers is reported in all townships.

Dry Zone (Magway and Mandalay regions): The preferred destination areas for internal labour migrants from the Dry Zone are: (i) Yangon, Nay Pyi Taw and Mandalay, for work in industrial zones, tea shops, restaurants, construction and petty trading, (ii) Shan State and Southeast to work in tea, sugarcane and rubber plantations, mines; (iii) North Kachin State for work in gold and jade mines, (iv) central Dry Zone for crude oil. While work in the agriculture sector and crude oil extraction is seasonal in nature. Seasonal migration is high in the case of intra-State/region migration, whereas inter-region migration in the Dry Zone is more temporary in nature.

In Magway region, crude oil extraction attracts many internal migrants from the region and from neighbouring townships in Mandalay region. MinhlaTownship, a study site famous for crude oil extraction, attracts seasonal migrants from both Magway and Mandalay. Work is seasonal in nature from January to April. Workers return home during off-season to work in their farms. Most migrants are males of 18-50 years of age.

There is also an increase in international migration to China, Thailand, Malaysia, though it is still much lower compared to the Southeast or Shan State. However, some townships report very high international migration (Kyaupadaung, Natogyi in Mandalay region), while others have less (Patheingyi, Tada U in Mandalay region).

Stakeholder mapping and legal and institutional frameworks migration in Myanmar

Stakeholders and migration organization:

Informal: social networks: Internal migration is mostly organized relying on social networks and traditional trade/labour routes. With the traditional routes proving to be less attractive, there is more dependence on social networks in deciding when and where to move and in finding jobs. Social networkscan be family, relatives, friends, neighbors – the services of whom are mostly free of cost.

Formal:labour brokers: However, there are also cases where persons arranging the migration of labourers from origin to destination areas – also called labour brokers/agents – are paid either in cash or in kind. An example of such an internal seasonal labour migration arrangement between PathiengyiTownship and Tada U Township in Mandalay region was found.

Other stakeholders: There are very few organization, both government and non-government, working on internal migration management. Most organizations and activities focusing on internal migration are involved with Internally Displaced People (IDPs), but little on labour migrants.

Legal and institutional framework for migration in Myanmar: There is no specific legal or institutional framework yet to regulate/manage internal migration in Myanmar. However, other legal and institutional frameworks have some influence on internal migration. Permanent migrants also find it much easier to find work and settle in destination locations, if they are registered with the local authorities. During discussion with international organizations in Yangon, it was reported that there are incidences of human trafficking in internal migration as well; however during interview with various stakeholders this could not be verified.

The Department of Population, Ministry of Immigration and Population, is the apex body in migration management. As an initiative to integrate more closely with the other

ASEAN economies, steps have been taken up to address migration of labour force within these countries. Myanmar and Thailand have signed a MoU to promote more documented migration in order to protect the rights of Myanmar migrant workers in the Thailand. Many international organizations such as IOM, ILO, World Bank, World Vision International etc. and many donors are involved in migration management in Myanmar, particularly in anti-trafficking programs, health programs etc.

Impact on livelihood of households and communities

As migration is a livelihood strategy adopted by the households to improve their overall socio-economic situation, it in turn impacts all aspects of the life of families and communities.

Economic assets: As lack of year-round and sufficient livelihood opportunities is the major reason for people to migrate for work purpose, migration has positive impacts on the household economic situation. However, the extent of this improvement depends on the type of migration, skills and the sector of employment. Not all migrations are made for household income maximization but also for risk diversification. So internal migration has not only improved household incomes but also reduced the risks faced by farm households due to extreme weather conditions or price fluctuations in the farm sector.

Access to income: As construction is not mechanized in Myanmar, it is highly labour intensive. For many poor rural migrants, this provides one of the best options of employment in the urban areas in absence of any off-farm vacation and technical skills. As can be seen from the wages comparison, generally the highest wages are earned by unskilled migrant workers in construction work. While an unskilled worker earns 4000-4500 Kyat per day, a mason or carpenter earns 6000 Kyat per day. In the agriculture sector, wages range between 2000-5000 Kyat per day. However, 5000 Kyat is earned only for a short duration in a year and only in few areas. In most cases the wages are 2000-3000 Kyat per day.When the earnings are low, it is almost exclusively used for household consumption, which is the case in most seasonal migration case. However, when migration is temporary in nature and migrants come from medium income households, some saving is used for investing in small enterprises in native villages. Skills learnt in destination locations are also transferred to home villages.

Access to labour: Internal migration solves the problem of un-/under-employment as well as creates labour shortages. In general, farming, in Myanmar is highly labour intensive, as there is little mechanization. Thus, labour migration impacts labour availability which, in turn, impacts wages, agriculture production and crop yields and value. As seen in Kyaupadaung Township, the labour shortage has increased the wages in agriculture work. In almost all the sites visited, agriculture wages vary between the lean and peak season, due to the seasonality of labour demand in this sector. As agriculture is the major economic sector in rural Myanmar, and the internal migrants are mostly farmers or landless farm labours, the impact of internal seasonal labour migration is high in agriculture sector.

Access to land: Access to land is a major factor on the decision to migrate internally as well as internationally. And migration, in turn, has an impact on access to land for migrant households. For the poor with little or no land, internal migration is a survival strategy. The small incomes from the internal migration are hardly sufficient to actually purchase a piece of land, but it helps in paying off debts, thus reducing the loss of land to money lenders in the village. Hence, internal migration does help indirectly in the access to land situation of certain vulnerable households. International migration has sufficient returns to actually lead to the purchase of land at the origin place or nearby urban centers.

Access to services

Education and skills development: Generally, in interviews with migrant workers, it is reported that migration has improved access to education of their children, as against the general belief that internal seasonal migration hampers education of children. For example, children of rubber plantation workers are believed to be lacking access to schooling. While studying the impact of migration on education, it is important to do a comparative situation analysis not only between the migrant and non-migrant population, and but also the situation of migrants in their origin and destination locations.

Access to health: It is generally believed that migration exposes the migrant population to high risks of diseases such as malaria, tuberculosis, HIV/AIDS, etc. due to mobility and work environment. For example, work in forests and plantations are considered high risk occupations for malaria infection (IOM, 2013); thus, working in mines and rubber would expose migrants to such risks. It is particularly so in rubber plantations, as most work is done during night time. An IOM study (2013) on access to public health by mobile and migrant population conducted in all the 10 townships in Mon state indicates that migrants had access to public health facilities within 15-30 minutes by car with the costs between 500-8000 Kyat. During interview with migrant workers, it was reported that remittances help them to better cope with financing medical treatment of ill household members. So, migration seems also to have a positive impact on the health of their family members.

Social assets

Household/family: Interviews with the migration-related households and migrants reveal that internal migration has not caused tangible threats in family harmony. As mostly young men and women migrate and as a household head is rarely involved in internal migration, the hierarchy and the decision-making structure within the family remains mostly the same.

Society/community: Impact of migration on social harmony/social hierarchy varies between the destination and origin location and the type of migration and remittance earned. In Mon State, immigration is reported to have increased social tension. Migrants are blamed for increase in crime rates in the area (stealing, robbery); and local people generally report feeling unsafe around migrant settlements. This has resulted in some conflicts between the migrants and local communities, resulting in fatalities. Such conflicts were reported in Ye, Kyaikmaraw

and Thanbyuzayat townships. The armed group together with villagers had tracked the migrant group and killed them. Such severe incidences are rare, but many incidences of migrants taking advance money for the work and then absconding were reported. Even children of migrant workers are reported to be discriminated in the school. No such strong negative feelings were expressed in Shan State.

Gendered impact of migration: As migration is not gender neutral, it is expected that migration would have impact on the gender situation in source communities. However, interviews with migrants did not reveal any such significant impacts. Overall, it is agreed that women are slowly taking a lead in farming but no reports were made on drastic changes in gender division of labour (changes in traditional male and female roles in society or farming) or decision-making as a result of migration. This could be because, unlike international migration, migrants involved in internal migration retain much stronger ties with their families left behind.

Conclusion

Internal migration is an important livelihood strategy undertaken by smallholder and landless rural populations to increase their income and employment security and options. The major reason for internal migration is the lack of year-round and sufficient income opportunities in the source locations and the demand for the labour in destination locations. However, there is a gradual trend in internal migration to progress from seasonal to year round temporary migration and permanent migration, and eventually to international migration.

More than wage difference, the lack of availability of off-farm work and seasonality of agriculture sector is the major cause of internal migration. Among the various sectors in which internal migrants are found working, construction sector provides higher wages for unskilled rural population. However, this sector also entails higher risks of work site accident, which when coupled of lack of health insurance, makes it more riskier option.

Internal migration is generally a survival strategy rather than wealth accumulation strategy. The earning capacity is much higher in international migration compared to internal migration, when migration is successful. While a successful international migration can lead to accumulation of land, small business, a successful internal migration is still limited to bridging gaps in consumption demands of the household members. However, there is some evidence suggesting that even the small savings from internal migration can be invested in SMEs provided there are favorable conditions (household members willing and skilled enough to look after the enterprises).

Internal migration takes place based on the existing social networks. Some of the migration routes are traditional such as from Dry Zone to Shan State to work in the tea plantations and to the mines in Southeast Myanmar. However, with the changes in prices of the crops, these traditional routes are losing its attraction and new route and sector are emerging such as construction. Among the internal migration steam, intra-state migration is very high in Shan and Mon state. In the Dry Zone both intra and inter-state migration is popular. Intra-state migration is more seasonal in nature and inter-state migration temporary or permanent in nature. One interesting finding is the organization of youth in some source communities for migration purpose which could also provide a good base for development interventions focused on youth.

Acknowledgement: Authors wish to thank HELVETAS MYANMAR for financial support of the study. This report is based on Internal Labour Migration Study in the Dry Zone, Shan State and the Southeast of Myanmar, published by HELVETAS Swiss Intercooperation in Myanmar in February 2015. HELVETAS Myanmar is not responsible for any discrepancies or views expressed. For the full report, please visit: https://www.myanmar.helvetas.org/en/projects/studies/

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J. Agrofor. Environ. 11 (1 & 2): 149-154, 2017 ISSN 1995-6983

Food security and socio-economic impacts of soil salinization in the central dry zone of Myanmar: a case study

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Abstract: The study area, HteinKanGyi village in Myittha Township, Mandalay Division is located in the Central Dry Zone (CDZ) of Myanmar. The central Myanmar is known as Dry Zone because of its physical characteristics such as low annual precipitation, instable distribution pattern, significant high temperature and low relative humidity. In the study area, more than 700 acres of the land is salt-affected due to the water logging from the result of left main canal system of Kinda Dam. Soil salinity has been one of the most important issues for local farmers who live in this village. Decreasing soil productivity caused by salinization has led to social tension, unemployment and reducing incomes of all households. This study surveyed the impacts of soil salinity on the crop production and to describe the food security and social and economic conditions in the HteinKanGyi village, Myittha Township. All respondents have more or less acreage of salt affected soil. Some people had no cultivated rice fields because of severe affected by salinity, and thereby families survive mainly as seasonal agricultural laborers. General socio-economic characteristics of the studied village are high population density, low agricultural productivity, low technological base, low producer prices, high costs and diminished margins, limited access to institutional credit, high degree of indebtedness, large percentage of landlessness, high incidence of seasonal migration, shortage of labor supply on large holdings and limited alternative income sources. This finding could suggest that development extension agencies should provide farmers with financial and technical assistance to make available salt tolerant rice varieties, knowledge and improved technologies in order to increase food sufficiency.
Key words: Food security, socio-economic, salinity, dry zone, Myanmar.

Introduction

Soil salinization has become a serious problem all over the world and around 20% of the world's cultivated land are affected (Sumner, 2000). In Myanmar, soil salinization was found in coastal and inland regions. Coastal salinity was affected by seawater intrusion/ infiltration during flood resulting salt accumulation in the top soil in the summer season. It was commonly happened in Ayeyarwady, Yangon, Yakhaing and Taninthari regions. Inland salinity is commonly seen in dry zone areas of the central Myanmar such as Mandalay, Magway and Sagaing regions. Among the three regions, salinity areas were mostly observed in 16 townships of Mandalay region with total areas of 6,357 ha in 2013-2014. Meikhtila district has the largest salt affected area of 3,045 ha followed by Myingyan (1,530 ha) and Kyaukse (1,125 ha)Districts. In the township level, the largest salt affected areas were found in Nahtogyi, Myittha and Wuntwin Townships with the areas of 940 ha, 617 ha and 437 ha, respectively (Swe and Ando, 2017). According to Swe and Ando (2017), salinity is becoming a prominent abiotic problem declining rice production in central dry zone where little attention was paid in the past. They opined that with irrigation for several years continuously, alkali/saline soils have been developed in certain areas. The excessive applications of irrigation water have raised the ground water level sufficiently to increase concentration of salts through evaporation. It is related principally to the presence of sodium carbonate and sodium bicarbonate in these particular areas. Inland salinity or irrigation salinity is due to over-watering, seepage from irrigation channel, impaired natural drainage and high water table. From the low land rice in these salt affected areas, high rate of evaporation and evapotranspiration of rice crop increase the capillary transport of water and solutes from the groundwater to the root zone. When there is a condition of no or negligible leaching of these salts, the soils will be affected with salinity within a few years. In addition, due to the poor drainage facilities in the irrigation areas not only the agricultural lands have suffered but also agricultural production has suffered from the twin hazard of water logging (hypoxia) and salinity. It has been happened for more than two decades in HteinKanGyi and thus causing threat to the local farmers' survival. The lands which are severely affected by water logging and salinity have gone out of production as an abandoned field because it has been caused to the agricultural production of lands.

In Myanmar, development of agriculture is vital to any rural development promotion effort. Broad-based and economically efficient rural growth can significantly help to reduce rural poverty and enhance food sufficiency by bringing about sustainable increase in crop productivity and reducing risks and vulnerability for the poorest population.

Soil salinity has been accelerated by human activities such as deforestation, irrigation, salt-making and construction of roads and reservoirs (Mitsuchi *et al*., 1986). In Myanmar, especially in the dry zone, declining soil productivity caused by saline intrusionhas led to the farmers in terms of social tension, unemployment and reducing incomes of all social groups. Increasing soil salinization affects many farmers in the dry zone with small land holdings. Soil salinization must be seen as also a human problem rather than one concerned solely with the damage of ecosystems. While people are the main agents for salinization, they are also its victim.

Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (WFS, 1996). The entire livelihood system of farmers in the central of Myanmar is farm-based. Farmers continue to make their living from manual trade and agricultural production. Rice, ground nut, sesame, lablab bean and pigeonpea are the main crops grown under rainfed conditions by practicing traditional cultivation system, and rice is the staple crop of most farm households in the studied area. Due to water

logging and soil salinization affected by irrigation canal of Kinda dam, low productivity has brought poverty leading to the lowest per capita income in the village. Their dependency on agriculture and lack of knowledge on management might have caused problems of salinization which has a severe effect on soil fertility and crop productivity. Therefore, it requires an examination in order to get a solution to this problem for a better livelihood of future generations. However, no research has been undertaken on an evaluation of the livelihood system in salt-affected areas of this region.Yet rice sufficiency is the key to survival in Myanmar as rice forms the greatest portion of daily food consumption for subsistence farmers. The objectives of this study were (i) to assess the influences of soil salinity on the rice production systems, and (ii) to describe the food sufficiency and social and economic conditions in the salt-affected areas of HteinKanGyi village.

Materials and Methods

This study aims to understand farmers' knowledge, practices and related problems and constraints in the crop production system and their food security status and social and economic conditions undersalt-affected areas of HteinKanGyi village in Myittha Township, Mandalay Division, Myanmar.

Site selection: A study area was selected in the central dry zone of Myanmar, representing the tropical climate zone. This study site was purposely selected because they have different salinity levels. Soil salinization continues to affect the farmers' livelihoods. This study was conducted in villages at HteinKanGyi village in Myittha Township, Mandalay Division, Myanmar from October to December, 2016.

Research tools: Research methods used in this study include a small questionnaire, semi-structured interviews, and direct observation. The small questionnaire was used in collecting quantitative data. Semi-structured interviews were used in collecting qualitative data and separate guidelines for key informants and household informants were used. This was because holding a well-prepared interview guide in hand, semi-structured interviews are more likely to cover all sub-topics of interest, and thereby reducing the potential risk of missing data. Direct observations were made in order to validate information given by informants (IFAD, 2002).

Data collection: The interview and information collection process was used as follows: (i) key informant interview and group interview in village level (ii) household level in-depth interview and (iii) observations. A simple random sampling method was applied to select sites and draw a representative sample of household heads for the study. The total sample size of households was drawn using simple random sampling technique, in view of that the sample of this study consisted of (30) households with facing salinity problems. The simple size was determined by Yamane (1967).

Data analysis: Qualitative data was supported by documents and materials relating to the topics covered by the study and the quantitative component of the study. Field notes were converted into detailed notes each day in the field soon after completing all interview sessions of the day. When the entire data collection process was completed, descriptive methods were used in data analysis. Quantitative data was analyzed by applying descriptive statistics (mean, percentage, etc.) with the help of Microsoft Excel.

Results and Discussion

Village profile: The geographical topography of Myanmar is divided into three parts such as western hills region, central valley region and eastern hills region. The study village, HteinKanGyi, is situated in Myittha Township, Mandalay, the central valley region and falls in the dry zone with tropical climate. It is situated 90 kilometers away from Mandalay city and 25 kilometers from Myittha Township. This village is located in the areas which are severely affected by water logging and salinity.

The characteristics of the households in the studied villages are shown in Table 1. There are 2232 people in this village and living in 587 households. 43 % of the total household are farmers and the rest are landless. Most of farmers have only lowland and a few has both lowland and upland. The total area of the study village is 4000 acres with the cultivated area of 2875 acre for lowland rice and 700 acre for upland crops. In lowland area, more than 700 acres of the land is salt-affected due to the water logging from the result of left main canal system of Kinda Dam. Most farmers grow rice on their salt-affected land while some grow green gram, pigeon pea and sesame in upland. Because of high salinity in this study site, some farmers abandoned their rice field after the five to six years of the completion of Kinda dam according to the group discussion. Because of the spread of salt-affected areas in this village, the current productivity of arable land areas is very limited. Major soil types found in this village are sandy soil, loamy sand, sandy loam soil.

Table 1. Characteristics of the study households in HteinKanGyi, Myittha Township

Characteristics	HteinKanGyi
Total households	587 (2232 populations)
No. of agricultural households	250
Salt-affected households	70
Sample households	30
Average age of respondents (year)	55 (36 ; 72)
Education (%) Primary school	60
Secondary school	40
Average household size (person)	4.1 (2 ; 6)
Average labors (person)	2.4 (1 ; 5)
Average number of dependents (person)	1.6 (0 ; 5)
Salt-affected area (ac)	722
Abandoned land (ac)	200

Parentheses show minimum and maximum.

According to group discussion, there is a minimum temperature range from 10˚C to 20˚C in December, January and February to a maximum of 43˚C in March, April and May. The hottest month is May and the coldest month is January. Temperature gradually rises during the

period between mid-March to mid-May, which is the pre-monsoon period, during which low pressure is created. The average annual humidity is 66 %, butit drops to 42 % in hottest months (April and May), whereas it shoots up to 80 % in wettest months.

Rainfall is also controlled by the monsoon circulation system. But rainfalls in the dry zone areas are sometimes come by tropical storms. Precipitation in early monsoon is favorable for crops in the village, if late, the crop yield is not certain for that year. All villages are located in semi-arid area so the farmers have adapted to climatic constraints. Based on their traditional knowledge, some farmers forecast on intensity of rainfall and grow different cropping patterns. Some farmers record the daily rainfall and list annually so they can make a decision on selection of crop variety for that particular year. The farmers from the village mentioned that precipitation varies from year to year, and even though the frequency of rainfall might be higher than normal, the amount of precipitation received may not be enough for the crops.

Soil salinity and rice production in the studied village: Swe and Ando (2017) noticed that in central Myanmar irrigated rice was cultivated since the ancient Myanmar King era of 11thCentury. Since the capitals of the kingdom were situated in Upper Myanmar where the climate is semi-arid, the kings constructed irrigation structures, such as weirs, lakes and canals. King Anawrahta (1044-1077) constructed seven weirs along the Zawgyi and Panlaung rivers and developed Ledwin - eleven- districts to produce sufficient rice for his entire kingdom. Since then, the new irrigation works were constructed; maintained, and renovated by the successive kings, making the irrigated rice production successful in upper Myanmar. In those days, irrigation system was mainly with gravitational flow and only for the monsoon rice cultivation.

In this study, according to the survey, the total irrigated area of Kingda Dam was allocated for 195260 acres which covers four townships, namely Myittha, Kyaukse, Tada-Oo, and Wundwin Townships (Irrigation Department, MOAI). Water from the dam is diverted into two main canals (Left Canal and Right Canal). The left canal of Kinda Dam was 78 miles long with total diversion canals of (DY) 34 in numbers and the flow rate of 1,948 cu.ft/sec. Total irrigated areas of the left canal of Kinda Dam were 65748 ac, while the right canal with 38895 ac (Irrigation Department, MOAI). Tun *et al*. (2009) observed that after three years of Kinda Dam irrigation the salt-affected area was formed about 41 acres. The water logging area increased yearly and it reached 722 acres and the related salt affected area was approximately 2500 acres in 1994-95.

Rice is the major staple food in Myanmar. All of respondents from the studied village are farmers, whose main occupation is the cultivation of rice for household consumption.There are two varieties of rice grown in the village namely Manawthuka in rainfed and Shwemanaw in the dry season. Due to the salinization, limitation of water resources, low soil fertility, high cost of capital investment for land preparation such as sowing, seedling, equipment, chemical fertilizer, pesticide, transportation and high cost of labor, the rice productivity is quite low. This situation has made the farmers face the problem of food insecurity. The villagers mentioned that the expenses of agricultural inputs have increased every year, especially fertilizer and pesticide. Farmers mentioned that rice price is not stable, and in some years the fluctuation is also high.

Rice production practices: According to the group discussion farmers starts land preparation at the onset of the rainy season in this village. Ploughing and harrowing and leveling are done by cattle. For land preparation, the land is ploughed at least 2-3 times followed by harrowing and leveling. Urea, compound fertilizers and cattle manure are commonly used as inputs in their fields. According to the group discussion, there are two methods of rice growing; transplanting and broadcasting in the village. The transplanting method is the most common for the monsoon season crop. For transplanting method, rice seedling is grown in the nursery for 30 to 35 days according to the varieties. Then, the rice seedlings are transplanted into the prepared paddy field. With the broadcasting system, farmers are unable to solve the weed infestation problem effectively because weeding totally depends on the manual control system and the farm labor charge to get the effective control might amount 30% to 50% of the total production cost which is unaffordable. Usually, monsoon paddy grows forabout 140 days in the field, from early-June to November. In the dry season, farmers grow irrigated rice by the broadcasting system. Unfortunately, in the summer season of 2016, there was no water for irrigated rice growing due to low precipitation in 2015.

At the harvesting time, the farmers in the village harvested rice by using a sickle. They reported that the whole rice plants are harvested by hand and the rice straw are kept for the fodder of cattle. Threshing is undertaken by a foot operated thresher by some farmers. However, most farmers preferred to use mechanized threshers. They reported that they can reduce the labor input requirements and it can be used quickly and efficiently. However, some farmers also reported that there is a lower level of seed viability of seed processed using mechanical threshers when compared with traditional practices. Most farmers undertake the storage of their rice grain in a barn for the seed of next growing season. Storage in barn is generally regarded as being capable of providing easier control of rodents and other pests.

It was observed that rice yields pre acre of the studied village for the year 2015 were much lower than those for the year 2014. This yield decrease for most households was apparently due to a prolonged drought in 2015.

The main problem with rice production in the studied village is salinity in the fields. According to observation, rice plants are affected by iron (Fe) toxicity under rice field with high salinity. Farmers could not cure this toxicity due to lack of knowledge and investment and consequently, the yield are very low. Farmers mentioned that there is another problem with the rice production that occurs about the time of harvest; damage can occur due to rodents and birds. Also, unseasonable rainfall (i.e. late rains) at harvest time can cause grain damage due to fungal diseases.

Socio-economic conditions: All villagers are Buddhists and they strongly believe in Buddha's teachings. They value the ordination ceremony when their son or grandson becomes a novice monk. All of the temple donations are based on agricultural income.

According to the elder villager, in years before constructing the Kinda dam, their lands were favorable for high productivity of crops. At that time, their standard of living was better so they could use the surplus for donations. All of the families do their social, cultural and religious activities after harvesting their cultivated crops.

In social, cultural and religious activities, the old persons and village headman play an important role. Even though the village headman has full authority, he shows respects to the old, honorable persons and follows the guidelines and suggestions from them. For the religious activities, monks play very important role in the village. In some social and cultural problems, monks can give the final decision for the village. Seasonal religious festivals are held under the guidance of the monks and elder person.

Although the major crop grown in the village is rainfed rice, some farmers grow sesame, pigeon pea, lablab bean and greem gram. Domestic animals raised by most farm households in the village are cattle, goat, pig and chicken for home consumption and sale.

The village economy is based on agriculture in the studied village. Most households are farm households, and very few households do non-farm work like government officials, public health workers, agricultural input retailer or small shopkeeper. The major source of income for the farm households in studied village is the cultivation of crops and keeping domestic animals like cattle, pigs and chicken also make a contribution to household income. They also spend certain amount money on their children's education, health, transportation, clothing, lightening, kitchenware, house maintenance, donation and personal use. In most cases, farm work is done using family labor, but hired labor is common during peak seasons like transplanting and harvesting of the crops.

House type is a relevant indicator for the economic status, especially the cash income of farm households in the village. Generally houses with corrugated iron sheet (CI) roofing and brick walls are owned by high income households. Slate-roofed houses with wooden walls are owned by middle income households, and thatch-roofed houses with bamboo walls by low income households. But some medium and low income households are roofed with CI with the wooden walls.

Table 2. Comparison of soil salinity level, average rice yield and average household's income of the studied village in the year 2016

Salinity level	Average rice yield (ton/ha)	Household's income (US$/year)	Source of income
High	1.35	770	Farm-based
Moderate	2.85	1077	Farm-based
Low	4.45	1540	Farm-based

Survey data (2016)

According to the group discussion, the average of rice yields among the sample household is very low about 2.5 ton/ha (50 basket/ac), as compared to the national average yield 4.07 ton/ha of (MOAI, 2015). This low yield might be due to the salinity, low soil fertility and sandy texture soil. The main source of household income in the village was farm-based. The study indicates that 80% of the total income in the studied village comes from the rice cultivation. Table 2 shows the comparison of soil salinity level, average rice yield and average household's income in year 2015. Farmers who have paddy field with high salinity level got an average yield of 1.35 ton/ha and annual household' income was US$ 770. In contrast, farmers who have paddy field with low salinity level got an average yield of 4.45 ton/ha and annual household' income was US$ 1540. It was found that the annual average income per household among the study household is US$ 985. Thus, salinity intrusion is one of the major environmental factors pushing towards greatest vulnerability to the local communities.

Village food security: Myanmar produces more than enough food to meet domestic needs and is a major food exporter, abundant food supplies do not automatically translate into abundant food for the poorer groups who live in the dry zone areas. Based on group interview, there are different types of agricultural and non-agricultural activities in the village practiced by the farmers in order to improve food security of their families. Generally, there are ten different agricultural activities (rice, pigeon pea, raising animals, etc.) and four non-agricultural activities (retail shop, daily labor migration to city, etc.) but not all households get involved in those activities.

Fig. 1. Percentage of respondents facing food deficit during the year 2015

Seasonality plays a vital role in food security. There was a persistent food scarcity during the growing of crops and the pre-harvest period, when farmers have to invest a lot of

money in such time. Most households in this study face food deficit more or less throughout the year (Fig. 1). The food deficit remains high from July to end of October (87-96 %), whereas it is the lowest in November and December (7-23 %) due to harvesting period for rice and growth of vegetables. There was also food shortage from February to May (57-77 %) due to lack of job in the dry season. This is due to no irrigation water in 2015 as most of the lands were not cultivated and food items are not easily available. They thus have to generate resources by selling food grains and cash crops, or by borrowing. Farmers have to tighten their grip on consumption during this time. They have to cook less compared to other times. Sometimes the men in the household temporarily migrate to the city for earning, leaving their family members at home. The food deficit is less during the month December–January due to harvesting period for rice and growth of vegetables.

Coping strategies: It was found that all farm households in the village were rice insufficient in 2015 due to salinity and prolong drought period. In order to survive throughout the year, rice insufficient households involved in various activities in quest for food or cash for food. Coping strategies are many and various in kind that only some selected, major activities are described in this report. In reality, many activates called "coping strategies food insufficiency" in this study are routine activities for some food sufficient households in generating their supplementary incomes. These activities can be briefly categorized as (1) farm-based strategies; (2) non-farm strategies; and (3) forest-based strategies.

Farm-based strategies are those activities directly related to cash crops or alternative food crops, and domestic animals. These include legume cultivation, and rising of domestic animals like cattle, goats, pigs, and chicken, etc. Non-farm strategies in this study mean such activities done for cash by selling or directly utilizing one's labor. Non-farm strategies include waged labor, migrated labor, and retailing. Forest-based strategies are those non-formal activities usually done by landless and small households during most difficult situations in time of hunger. They include mushroom and bamboo shoot collecting in the forest, firewood collecting. Although the study area is under forest conservation some landless and small farmers used to cut branches of big trees and it is still a simple coping strategy for food insufficiency in a shortest period of time.

Labor migration also increasingly becomes a major coping strategy for food insufficiency in the village. Twenty percent of farm households have migrated to the city as seasonal labor to other farm where watermelon was grown. The most common destination migrants from the village is Mandalay. Among those who migrate to the city, males remit more money to their homes than females do. Male migrants usually do hard works of higher wage rate, but their remittance is not regular.

In the studied village, most survey households are not entirely self-sufficient and need to integrate into the labor market as employers and laborers. As such, food insufficient households in the village also perform various non-farm activities as their survival strategies. For landless and marginal farm household with salinity problem in the village, labor migration is at first another strategy for coping with food insufficiency. The people from the farm household migrate in search of higher wage as it happens in the city or other agricultural farm.

Conclusion and suggestion

Salinity intrusion caused by irrigation canal from Kinda dam is leading to negative impacts on rice production and consequently to the food insecurity and livelihood of the studied village.

The studied village face enormous widespread soil salinity as a consequence of soil and water resource degradation. Also, rising water tables resulting from irrigation have caused water logging problems. The collected information shows that despite difficulties, farmers are continuing their efforts for the management of salinity to produce rice. In order to alleviate salinity in their rice field, they apply organic fertilizer and farmyard manure such as cattle manure. However, the average of rice yields among the sample household is very low about 2.5 ton/ha (50 basket/ac). In addition to salinity effect, periodic drought, the heavy reliance on monsoon, lack of financial capital, low inputs uses are the major constraints for the farmers in the village.

This finding could suggest that farmers are advised to use farmyard manure and green manure in order to reduce salinity, correct application of fertilizers, the timely use of fertilizer, better weeding, timely harvesting and proper threshing and winnowing. Since rice is the main source of livelihood system, extension agencies should provide farmers with financial and technical assistance to make available salt tolerant rice varieties, knowledge and improved technologies in order to increase food sufficiency.

Acknowledgements: This study was supported by the Center for Southeast Asian Studies (CSEAS), Kyoto University, Japan

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J. Agrofor. Environ. 11 (1 & 2): 155-157, 2017 ISSN 1995-6983

Extent of forest fire problems – its sustainable development strategies in Bhutan

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Abstract: Bhutan has the total land area of 38,394 square kilometres and 72.5% of the land is under the forest cover. Forest is the source of livelihood and it is the most important wealth of Bhutan. Furthermore, forest in Bhutan is the vital source of water for hydro powered-industries which are currently the main revenue generators for the nation. There is a high concern to protect and conserve the environment. In fact, the protection and conservation of the environment is one of the pillars of Gross National Happiness (GNH). However, given the rights of the people to graze on the government registered land and harvest lemon grass for lemon oil extraction, the people widely practise burning of forest to have new grass growth for oil and cattle. Fires also result from the practice of burning agricultural debris. Therefore, qualitative data was used to explore and compare the statistical data base of forest fires in 1981-1985, 1988-2004 and 2008-2011. It demonstrates that the country has experienced a total of 1,432 cases of forest fires since 1981 till 2011 and has adversely afected a total of 868,086.313 acres of forests in Bhutan. It also shows that Bhutan experienced a maximum forest fires between the year 1988 and 2004, with the least 38 and the highest 112 cases of forest fires annually. Fortunately, the data of 2008 and 2011 indicate that the cases of forest fires have declined as it reflects not more than 74 numbers of forest fire incidents within two years. Nonetheless, forest fires are a deterrent to the sustainability of forest cover in Bhutan. Therefore, if left unchecked, there is a potential danger that the trend may escalate with the growth in the population and growing economy. Therefore, this study suggests that Royal Government of Bhutan has to continue with the serious sustainable measures to sustain forest with better means of public friendly educative alternatives to fulfill the constitutional commitment of 60% of forest at all times to come.
Key words: Forest, fire conservation, grazing, lemon oil, sustainable.

Introduction

The kingdom of Bhutan is a sovereign nation located in the eastern Himalayas. It is one of the smallest nations in the Asian region, sandwiched between the two populous countries of China in the north and India in the south. Bhutan has the total area of *38,394* square kilometres with 72.5% forest cover (NSB, 2010). Bhutan, albeit a small nation, was a winner of the 2004 "Champion of the Earth" (Kuensel, 2005) and the "World Conservation Leadership Award" (Kuensel, 2006) and awaits the award from World Council for the constitutional commitments to maintain 60% forest cover at all times (Third Annual Report, 2011). Today Bhutan is also recognised as the 17th most forested country in the World. So Bhutan strives to continue the same but as a developing nation, with the growth in the population and growing economy, environmental problems are not spared.

Therefore, this paper presents the comparative statistics of forest fires and its extent of damage since 1981 till 2011. It also shares the experiences of its mitigation and intervention strategies to reduce the risk of forest fires.

Materials and Methods

The qualitative method is applied to undertake this study. The facts and figures are largely based on secondary sources, particularly the fire statistical data base of 1981-1985, 1988-2004 and 2008-2011 to have comparative studies of forest fire trends and to explore to what extent it has hindered the pursuit of sustainable forest management and economy in parallel. Likewise, secondary sources such as national newspapers, the Kuensel, and Bhutan observer, the private newspapers are extensively referred as they covered most of the environment related topics and latest environment updates. Several reports and acts are also referred.

Results and Discussion

Extent of forest fire Problem:

Although Bhutan Forest Fire Act 1969 (FFA, 1969) and the Forest and Nature Conservation Act of Bhutan 1995 (FNCA, 1995) prohibit forest fires, punishable with an imprisonment of five years, yet burning forests continues at an alarming rate. It seriously undermines a serene environment. Fire statistics of Bhutan in the past and present indicate the pervasive problem of forest fires although the intensity fluctuates resulted either intentionally or accidentally. The statistical database of wild fires in Bhutan between the years 1981-1985 (Table 1) shows that Bhutan experienced a total of 232 cases of forest fires, damaging 29,616 hectares of forested area. Likewise, the information data between 1988-1994 and 2008-2011(Table 2 and 3) demonstrate that Bhutan has experienced forest fires not less than 35 times a year.

According to Dorji (2004a), A total of 868 fire cases were reported between 1993-2005 which affected 128,368 hectares of pristine environment. In 2006, Trashigang district experienced major fire which burnt about 1000 ha and similarly in 2006-2007 record, a total of 15000 ha were burnt by a single major fire in Wangdue District. In 2007 Fire our breaks occurred in Tshirang and damaged 5000 ha of chir-pine *(Pinus roburghil)* of forests.

Similarly, Kuensel (2010) reported that Trashigang experienced another major fire in Chenari which has gutted down an automobile workshop, 3 cars, 25 two-wheelers kept for repair and burnt one sawmill along with the construction material ,a house and makeshift labour camps at Kheri. The fire also damaged 150 disc insulators of Chenari power house. The data of forest fires between 2008 and 2011, indicate a total of 31,132.00 acres of forests was lost to deliberate wild fires. Therefore, these figures indicate that forest fires seriously impede sustainable management of forest resources in Bhutan.

Causatii ve Factor s:

There are many underr lining causes for the outbreak of rampant forest fires in Bhutann. Fig. 1 (below) sum up that the fires are either caused intentionally or accidentally. According to Doorji (2004b), 88 percent of wild fires are caused by human activities while 155 per cent and 5 per cent are the result of accidental and unknown cases. Similarly Gyeltshen (n.d.) mentioned the caa uses of the wild fires as per there port of the forest

research centre shows that human made causes are 100 per cent. All in all, the study shows that the main culprit for the forest fires in Bhutan is human madee which is 100 per cent. Their deliberate actions are for the new growth of lemon grass for oil extraction, debris burning for agricultural purposes, setting forest on fire foor cattle feeding and to some extent, due to the result of human carelesness such as throwing cigarette butts with fire intact.

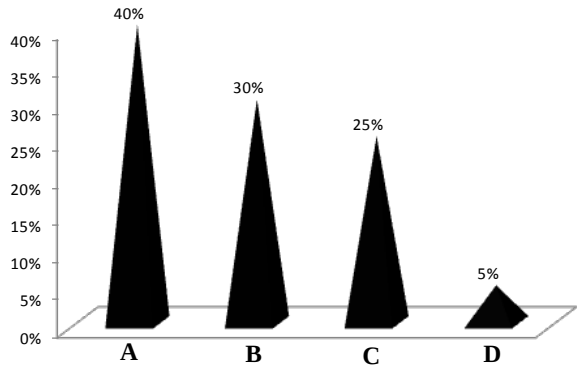

Fig. 1. The causes of forest fire (A) intention buring for new grass cultivation for cattle, (B) buring trees to prepare grazing areas, (C) camps and cooking fire, and (D) discarded cigerrates.

Table 1. Statistical database of forest fires in 1981-1985.

Year	No. of fires	Area Burned(ha)
1981-82	74	12,843
1982-83	64	5,487
1983-84	47	7,243
1984-85	47	3,943
Total	232	29,616

Source: Royal Government of Bhutan

After having compared the statistics of fires in 1981-1985 (Table 1), 1988-2004 (Table 2) and 2008-2011 (Table 3), it shows that Bhutan has experienced a total of 1,432 cases of forest fires since 1981 till 2011 and has adversely affected a total of 868,086.313 acres of forests in Bhutan (1 ha = 2.47 acres of land). The data indicate that Bhutan experienced most of the forest fires between the year 1988 and 2004. The year 1999 was severely hit with 112 cases of forest fires affecting 33,839.88 hectares and the least in the year 1991 and 1992 with each 38 cases of forest fires (extent of damage not mentioned). Fortunately, with the serious measures of a sustainable forest policy in place, the data of 2008 and 2011 illustrate that human made forest fires have drastically declined with not more than 74 and less with 37 numbers of forest fires within the span of two years. Nonetheless, forest fires are a deterrent to the sustainability of forest cover in Bhutan. Hence, if left unchecked, there is a potential danger that the trend may escalate with the growth in the population and growing economy.

Table 2. Fire statistics in Bhutan during 1988-2004

Year	Total no, of fires on forest, other woodlot and other land	Area of forest burned (ha)
1988	46	NA
1989	66	NA
1990	50	NA
1991	38	NA
1992	38	NA
1993	84	729957.44
1994	36	5601.96
1995	56	49069.31
1996	62	27030.26
1997	48	24633.3
1998	72	16218.2
1999	112	33839.88
2000	104	33638.34
2001	81	23314.2
2002	64	14644.16
2003	45	5723.49
2004	39	2561.36
Total	1081	309231.9

Forest fires were found mainly caused willfully by the desire to have either lemon grass or new grass for cattle and burning dry plants and grasses for agriculture in the field. If we are to let the trend to continue than, in the long run, it is likely hinder the achievement of the constitutional commitment of 60% of forest cover. Though the government has banned tseri practice of shifting cultivation to mitigate rampant damage of forest, people in some pockets of area do still practise the culture resulting in destroying a huge track of forested area. This has alerted the officials who are engaged in conserving the national environment.

Therefore, the Royal Government of Bhutan has to continue with the serious sustainable measures to sustain forest with better means of public-friendly alternatives to fulfil the constitutional commitment of 60% of forest at all times to come.

Table 3. Forest fire statistics in Bhutan during 2008-2011

Year	Average number of fire	Forest destruction by fire (acre)	Total destruction by fire (acre)
2008-2009	774	117	13105
2009-2010	448	190	99159.41
2010-2011	337	239	8867.594
Total	159		31132.00

Operational Fire Management strategies:

Although Bhutan continues to experience deliberate forest fires, the decision makers at national level continue to incorporate mitigation methods to combat the problem, as it unquestionably hinders a sustainable growth of forests and economy, and it also undermines the holistic sustainable development policy: GNH.

Therefore, to prevent the fire and support sustainable management of forests at the national level, the National Environment Commission (NEC) and National Forest Fire Management (NFFM) plan and execute forest fire awareness programmes, develop training modules in conjunction with media in informing and educating the public and train the field staff. Further, the Nature Forest Conservation and Forest 1995 (NFCF) and the National Forest Policy 1974 (NFP) provide the policy frame work for our successful conservation efforts for sustainable management of our rich yet fragile resources.

There are plans afoot to introduce the Geological Information System (GIS) system to sensitise and inform about the outbreak of forest fires and will help reducing the extent of forest being damaged.

Intervention:

In order to fulfil the constitutional commitment of 60% of forest covers at all times to come and to intentionally live up to the promise of the world to be a carbon neutral country by successfully phasing out HCFC by 2025 (Annual Report on the State of the Nation, 2011) and to realize the mission of sustainable development through GNH, the NEC and the DoF initiate programmes such as afforestation and reforestation. Interestingly, the villagers were asked to plant trees and, after certain years, the ones who have taken the best care and planted the maximum are rewarded. On 2 June every year, the nation celebrates as the Social Forestry Day and ensures that every individual of the country plants trees. Of late, the Ministry of Education has initiated a programme called 'Green Bhutan, Green schools' and the teachers and students are encouraged to plant and take care of trees and flowers in the school campuses. Furthermore, to reduce the risk of forest fires, the 'Forest Fire Volunteers Programme' was institutionalised with a total registration of 175 volunteers .These volunteers are engaged in creating an awareness of forest fire risks in schools and communities and National Forest Inventory was also carried out .Very recently, the government has also initiated community forestry for the sustainable management of forests.

Conclusion:

To conclude, the forest and natural environment play a pivotal role in providing sustainable livelihood to the Bhutanese people as the country is hugely dependent on them. However, forest fires have become imminent impediment to the natural setting thereby creating an imbalance ecosystem. This has the potential to create persistent repercussions to the environment at all times to come if proper measures are not instituted in time

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J. Agrofor. Environ. 11 (1 & 2): 159-162, 2017 ISSN 1995-6983

Yield performance of Paw San rice (*Oryza sativa* L.) group: Paw San morphotype

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Abstract: Paw San group rice varieties are important for local adaptability, grain quality, market availability and premium price, and have been cultivated for long time in Myanmar. Undesirable negative effect of mutation and out-crossing with other local varieties or common wild rice may lead to inter-varietal variation, and limited seed flow system for Paw San rice may also lead to varietal degradation. In 2008, lower part of Myanmar was hit by Cyclone Nargis, and some of the local rice varieties in Paw San area may lose forever. This study was carried out to test yield performance of 5 genotypes of Paw San morphotype at Myaungmya and Yezin in 2009, and some genotypes which produced higher grain yields seemed to be promising for future varietal improvement for development of Paw San rice.
Key words: Genotype, morphotype, Paw San, yield and yield components.

Introduction

Rice varietal groups in Myanmar have been standardized as *Emata*, *Letywezin*, *Ngasein*, *Meedon* and *Byat* in order to facilitate external and internal trade. Among them, Meedon rice area in 2007 was 449487 hectare, comprising 6.5% of total rice area in Myanmar, and mainly grown in rainfed lowland areas: Ayeyawady (52.1%), Yangon (27.9%), Yakhine (12.1%), Bago (4.5%), Mon (3.1%), and other Regions (0.3%) (MAS, 2008). Paw San rice varieties are included in *Meedon* group, and have been cultivated and maintained as on-farm conservation for centuries. Undesirable negative effect of mutation and out-crossing with other local varieties or common wild rice may lead to varietal variation, and since the possibility of the quality of some varieties show location specific, farmers in the areas used to grow their own seeds so that there was limited seed flow system for Paw San rice may lead to varietal degradation. On the other hand, the ability of low nitrogen tolerance, local adaptability, grain quality, market availability and premium price can extend the growing area for Paw San rice to the productive land such as favorable rainfed area and irrigated tract besides its native or marginal land of unpredictable flood in rainfed lowland. Therefore, Paw San rice varieties with high yield potential and wide adaptation may become essential.

Current national rice varietal improvement programs also focus on improving quality rice for regional and global rice trade competition. To improve rice varieties, breeding methods such as indigenous selection, selection of introduced entries, hybridization and mutation breeding can be used. By indigenous selection, varieties could be released in another adaptable area, and 13 local varieties had been released (Ohn Kyaw, 2002). Tin Tin Myint *et al.* (2004) also mentioned the indigenous selection and the release of 18 local varieties by this method. Small-scale, decentralized, farmer-participatory breeding and variety selection programs have been advocated to reduce genetic erosion by improving indigenous germplasm and exploiting local adaptation (Maurya *et al.*, 1988). In some cropping systems, such programs can increase crop genetic diversity when localized environmental constraints result in a failure of high-yield varieties to perform well (Witcombe *et al.*, 1996; Sthapit *et al*., 1996).

With the advent of genetics and plant breeding, selection has been intensified for high yield potential with broader adaptation (Simmond, 1979). Although rice entries can be introduced through international evaluation nursery program, utilization of local germplasm seemed to be suitable for greater adaptability to local special and temporal conditions. Genetic resources of Paw San rice were collected and conserved in Myanmar Seed Bank, and the study of Paw San rice germplasm showed a relatively high genetic diversity and elite accessions were identified (Min San Thein *et al*., 2011).

In 2008 May 2, Myanmar was hit by Cyclone "Nargis", the largest storm of its history, and the Nargis hit the two major Paw San rice growing areas, Ayeyawady and Yangon Regions. By this natural disaster, many stores of rice have been swept, and some of the local rice varieties may lose forever (PoNJA, 2008). On the other hand, there was also limited varietal improvement program for Paw San rice. Therefore, this study was carried out to test yield performance of elite Paw San accessions to identify promising genotypes.

Materials and Methods

Material: Five accessions viz. PS_1, PS_2, PS_3, PS_4 AND PS_5 were identified as elite genotypes by indigenous selection based on evaluation test in 2008 (Min San Thein *et al*., 2011). They were 5 genotypes of Paw San morphotype and those genotypes were used in yield performance trials. Local variety, Paw San Shwe War was used as check.

Experimental sites and design: Yield performance trials were conducted at the experimental fields of Myaungmya Agricultural Research Center, Ayeyawady Region and Seed Bank, DAR, Yezin, Nay Pyi Taw, Myanmar on 21 June 2009 and 27 June 2009, respectively. Yield trials were tested in RCB designs with four replications, and each plot was 4.0 m x 3.5 m. The seedlings were raised in nursery beds, and 30 days old seedlings were transplanted singly in each hill with a spacing of 25 cm between rows and 20 cm within row. Each plot consisted of 14 rows of 4.0 m long and 0.25 m apart. Each row consisted of 20 hills. Harvested area was 3.6 m x 3.0 m included 12 rows of 18 hills/row and total harvested hills were 216. A basal fertilizers application was 14:27:30 kg/ha of N: P_2O_5: K_2O followed by top-dressing of 14 kg N/ha at 45 days after transplanting. Grain yield/plot, yield components and other traits such as biomass/hill, harvest index, days to heading, plant height, and panicle length were measured.

Data analysis: Individual and combined analyses of variance (ANOVA) for yield trials with 4 replications at

Myaungmya and Yezin were computed using CropStat.Ver.7.2.2007.2, IRRI, Manila, Philippines.

Results and Discussion

Yield performance trials for Paw San genotypes: PS1, PS2, PS3, PS4 and PS5 with local check (Paw San Shwe War) were tested at two locations, Myaungmya and Yezin, and result of grain yield was shown in Table 1. The genotypes were not statistically significant at $P \leq 0.05$ level for Yezin location. However, it was significantly different ($P < 0.01$) for Myaungmya location.

Combined ANOVA was computed to determine the yield performance of genotypes across two locations. Genotype (G), location (L), and genotype - location interaction (G x L) were significantly different at $P < 0.01$ level of probability. When genotype (G) and location (L) effects were observed, location effect was greater than genotype effect as shown in Table 2. The mean yield (ton/ha) of 5 Paw San genotypes under two locations was shown in Table 3. When yield performances of genotypes were compared, mean yields were not significantly different at Yezin location. However, genotypes PS3 and PS5 produced significantly ($P < 0.01$) lower grain yield than local check at Myaungmya location and by combined analysis. Genotypes PS2 (3.897 ton/ha) and PS4 (3.606 ton/ha) gave more yield than check (3.441 ton/ha) but not statistically significant at Yezin location as well as PS2 (3.469 ton/ha) gave more yield than check (3.385 ton/ha) by combined analysis. When yield performance under two locations was compared, mean grain yield (3.502 ton/ha) at Yezin location was significantly ($P < 0.01$) higher than mean grain yield (2.788 ton/ha) at Myaungmya location.

Based on the results of ANOVA of grain yield for two locations, it was noted that test genotypes were not different at Yezin location while they were different at Myaungmya location. However, genotypes PS3 and PS5 produced significantly lower grain yield than local check at Myaungmya location (Table 4). It is suggested that there was more variable of environment in Myaungmya than in Yezin. Genotypes PS2 and PS4 produced more grain yield than check but not statistically significant at Yezin indicating the importance of those genotypes for conservation and use.

Table 1. Individual ANOVA of grain yield (ton/ha) for Paw San genotypes by locations

Source of variance	Degree of freedom	Sum of square	Mean square	P-value
	Yezin			
Genotype	5	0.9426	0.1885 ^{ns}	0.1450
Replication	3	0.5113	0.1704 ^{ns}	0.1970
Residual	15	1.4506	0.0967	
Total	23	2.9046	0.1263	
	Myaungmya			
Genotype	5	6.7653	1.3531 **	0.0010
Replication	3	3 .429919	0.1433 ^{ns}	0.3220
Residual	15	1.6997	0.1133	
Total	23	8.8950	0.3867	

** = significant at $P < 0.01$ level, * = significant at $P < 0.05$ level, ^{ns} = not significant

Combined analysis of the two locations indicates the differences among genotypes (G), locations (L), and genotype-location interaction (G x L). The greater effect of location (L) indicating the variability of the two locations that Yezin was irrigated tract where water requirement was controllable, whereas Myaungmya was rainfed lowland that unpredictable flood caused uncontrollable drainage or irrigation.

Table 2. Combined ANOVA of grain yield (ton/ha) for Paw San genotypes across two locations

Source of variance	Degree of freedom	Sum of square	Mean square	P-value
Genotype (G)	5	4.9504	0.9901 **	0.0000
Location (L)	1	6.1258	6.1258 **	0.0000
Replication (R)	3	0.4023	0.1341^{ns}	0.5104
Pooled error	38	6.4469	0.1697	
Total	47	17.9253	0.3814	
G x L	5	2.7575	0.5515 **	0.0020
G x R	15	2.6232	0.1749 ^{ns}	0.4440
L x R	3	0.9390	0.3130 ^{ns}	0.3780
G x L x R	15	0.5271	0.0351 ^{ns}	1.0000

Table 3. Mean yields (ton/ha) of Paw San genotypes tested in two locations

Genotype	Yezin	Myaungmya	Difference	Combined	Location
PS1	3.375 ^{ns}	3.182 ^{ns}	0.193	3.278 ^{ns}	
PS2	3.897 ^{ns}	3.042 ^{ns}	0.855	3.469 ^{ns}	
PS3	3.322 ^{ns}	2.069 **	1.253	2.696 **	
PS4	3.606 ^{ns}	3.077 ^{ns}	0.529	3.341 ^{ns}	
PS5	3.373 ^{ns}	2.027 **	1.346	2.700**	Yezin=3.502 **
Check	3.441	3.329	0.112	3.385	Myaungmya=2.788
Mean	3.502	2.788	0.714	3.145	3.145
SE	0.1555	0.1683		0.146	0.084
$LSD_{(0.05)}$	0.4687	0.5074		0.417	0.241
P-value	0.1449	0.0010		0.0005	0.0000
CV (%)	8.9	12.1		13.1	13.1

SE=standard error, $LSD_{(0.05)}$=least significant difference at P<0.05 probability level, CV=coefficient of variation

Table 4. Means of yield components of Paw San genotypes by two locations

Genotye	YLD	Gr/H	Gr/P	FGr/P	100W	ET	BIO	HI	DTH	PH	PNL
PS1	3540.5	17.4	3.42	114.1	2.71	6.4	78.7	0.235	140.9	147.7	28.0
PS2	3746.7	14.2	3.11	101.5	2.72	6.1	72.4	0.211	141.8	139.2	26.1
PS3	2911.3	13.7	2.57	88.9	2.60	7.4	84.0	0.165	145.8	148.6	27.0
PS4	3608.6	16.3	2.74	96.3	2.60	8.0	79.5	0.207	143.0	147.8	27.1
PS5	2916.2	13.0	2.42	87.8	2.55	7.2	74.1	0.195	145.3	147.1	27.5
Check	3655.9	26.0	2.92	113.4	2.56	9.9	80.8	0.329	139.9	132.2	25.8
Mean	3397.0	16.8	2.86	100.3	2.62	7.5	78.2	0.224	142.8	143.8	26.9
SE	157.3	1.091	0.167	6.102	0.029	0.436	3.991	0.015	0.432	1.269	0.386
LSD $_{(0.05)}$	450.2	3.123	0.477	17.470	0.082	1.249	11.430	0.044	1.237	3.633	1.106
P- (G)	0.001	0.000	0.002	0.010	0.000	0.000	0.341	0.000	0.000	0.000	0.002
P- (L)	0.000	0.000	0.001	0.801	0.006	0.000	0.000	0.112	0.000	0.000	0.485
P- (G x L)	0.002	0.194	0.611	0.469	0.843	0.387	0.000	0.104	0.000	0.265	0.237
CV (%)	13.1	18.4	16.5	17.2	3.1	16.4	14.4	19.3	0.9	2.5	4.1

Yld=grain yield/plot (g), Gr/H=grain weight/hill (g), Gr/P=grain weight/panicle (g), FGr/P=no. of filled grain/panicle, 100GW=100-grain weight (g), ET=no. of effective tiller, BIO=biomass/hill (g), HI=harvest index, DTH=days to heading (day), PH= plant height (cm), PNL=panicle length (cm), SE=standard error, $LSD_{(0.05)}$ =least significant difference at P < 0.05 probability level, P-=P-value, CV=coefficient of variation

The genotypes of three Paw San morphotypes were variable in grain yield and yield components, and some of the genotypes were important for yield potential and they seemed to be promising genotypes for utilization in varietal improvement. Those genotypes were PS2 (Acc. 1139) and PS4 (Acc. 2501), respectively (Table 5).

Table 5. List of 15 potential genotypes of Paw San morphotypes

Sr. no.	YT code no.	Accession no.	Local name	State/ Region
1	PS1	ACC. 930	Paw San Hmwe	Bago
2	PS2	ACC. 1139	Paw San Hmwe	Bago
3	PS3	ACC. 3225	Mee Don Yoe Sein	Ayeyawady
4	PS4	ACC. 2501	Paw San Hmwe	Yangon
5	PS5	ACC. 2522	Paw San Hmwe	Ayeyawady

YT=Yield trial

Conclusion

The two locations, Yezin and Myaungmya showed variation in terms of grain yield. Mean grain yields were generally greater in Yezin than in Myaungmya may be due to the favorable condition of water controllable irrigated tract of Yezin. Therefore, it could be concluded that most of the tested genotypes could produce higher grain yield in productive land of irrigated tract. Some of the tested accessions seemed to be promising genotypes, and they are important for their yield potential for conservation and use. Some accessions performed well in both locations although the locations differ substantially in rainfall, soil type and rice ecosystem. So, genotypes adapted to both locations were also important for conservation, and they could be useful genotypes for wider adaptation for varietal improvement of morphotype of Paw San rice.

Acknowledgement: The authors would like to thank Farm Manager and staff of Myaungmya Agricultural Research

Center, and Head and staff of Myanmar Seed Bank for support and assistance. Permission for this research was given by Director General of DAR, and the first author thanks to U Kyi Sein and staff of Advanced Agricultural Engineering Co. Ltd., Yangon, for support for Paw San rice group survey in Ayeyarwady Region.

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J. Agrofor. Environ. 11 (1 & 2): 163-164, 2017 ISSN 1995-6983

Mangrove and their Environment: the role of FREDA with particular reference to Myanmar

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Abstract: The mangrove environment in general and with particular reference to Myanmar has been reveiwed. The rehabilatation and conservation activities of Forest Resource Environment Development and Conservation (FREDA) in the wake of natural disaster like cyclone Nargis of 2008 have been stated elaborately. The future strategies in mitigating the adverse effects of global warming and climate change have brrn hilighted.
Key words: Mangrove environment, FREDA, Myanmar.

Mangrove forests are one of the important Ecosystems of Wetlands. Mangroves are important to people living near tropical and sub-tropical coastal regions as wood and food resources and also for coastal protection. They are also important from the global view point of the earth's natural environment. Mangrove environments are formed through strong feedback relations between biota, landform, water flow and the atmosphere. In fact, water flows play a very important role in mangrove ecosystems, differentiating from freshwater wetlands and terrestrial ecosystems. Mangrove areas are periodically inundated by brackish water, with salinity ranging from that of seawater to that of freshwater, usually twice a day by astronomical tides. The hydrodynamics caused by the tide and sea waves are the dominant physical factors affecting the mangrove ecosystems.

In Asian countries, where mangrove forests have been extensively degraded and even completely destroyed, mangroves and their ecosystem conservation is very essential not only for the natural disaster protection but also for the production for wood as well as marine products for food.

Southeast Asias' 563 million people are concentrated along coastlines measuring 173,251 kilometers long, leaving them exposed to rising sea levels. Where Myanmar has also a long coastline of 2,832 kilometers with a continental shelf area of 228,781 sq.kilometers. At the same time, the region's heavy reliance on agriculture for livelihoods – the sector accounted for 43% of total employment in 2004 and continued about 11% of gross domestic product (GDP) in 2006– make it vulnerable to droughts, floods and tropical cyclones associated with global warming and climate change. Its high economic dependence on natural resources and forestry as one of the world's biggest providers of forest products – also put it at risk. And increase in extreme weather events, deforestation, forest degradation and forest fires arising from climate change jeopardizes vital export industries.

Rapid economic growth and structural transformation in Southeast Asia helped lift millions out of extreme poverty in recent decades. But poverty incidence remains high as of 2005, about 93 million (18.8%). Southeast Asia still lived below the $ 1.25 a day poverty line and the poor are the most vulnerable to climate change. Mean temperature in this region increased 0.1-0.3°C per decade between 1951 and 2000; rainfall trended downward during 1960-2000; and sea levels have risen 1-3 millimeters per year. Heat waves, droughts, floods, and tropical cyclones have become more intense and frequent, causing extensive damage to poverty, assets, and human life. The number of recorded floods/ storms/ cyclones has risen dramatically recently. Cyclone Nargis of 2008, Giri of 2010, heavy rains and floods all over Myanmar and neighbouring countries are the current examples (Lateef. 2009).

The best and effective way to counter these natural disasters and to help and improve the livelihoods of coastal population is to preserve or protect the existing coastal mangroves and to restore or re-establish the degraded or depleted mangroves. The remaining mangroves of the world interms of area and percentages can be stated as follows:

Sl.	Country	Area(km^2)	% of world total
1	Indonesia	31,894	20.9
2	Brazil	13,000	8.5
3	Australia	9,910	6.5
4	Mexico	7,701	5.0
5	Nigeria	7,356	4.8
6	Malaysia	7,097	4.7
7	Myanmar	5,029	3.3
8	Bangladesh	4,951	3.2
9	Cuba	4,944	3.2
10	India	4,325	2.8
11	Papua New Guinea	4,265	2.8
12	Colombia	4,079	2.7

Distribution of mangroves in Myanmar may be stated as follows:

Name of Division/State	Area in ha	% of total
1. Ayeyarwady Division	87, 963	19.06
2. Mon State	21,265	4.61
3. Raknine State	141,883	30.73
4. Taninntharyi Division	200,034	43.33
5. Yangon Division	10,479	2.27

FREDA has been establishing community forestry plantations with mangrove species in Pyindaye and Kadonkani Reserve Forests, Ayeyarwady Delta where natural mangrove forests were depleted due to encroachment for rice cultivation and landuse change. Since the farmers have to abandon their rice fields after some years due to extrusion of salt water and acid sulphate from below, the only approach to address this issue is to restore the mangrove forests by the communities under the Community Forestry Instructions (CFI) of the Forest Department.

Extension activities for increased awareness, technology transfer and material support were undertaken by FREDA with the cooperation and support of international NGOs such as ACTMANG of Japan, DKH and EED of Germany. So far over 5,000 acres (> 2000 ha) of mangrove plantations are already established. FREDA has

established several nurseries to produce millions of mangrove seedlings for planting by the local communities.
Now FREDA is conducting 3 kinds of mangrove plantations such as CFI for fulfilling the basic needs of communities, village wood-lots for the protection of village communities and their assets as disaster prevention and the wind-break or shelter belt plantations along the sea-shores and stream banks to protect wind and wave erosions.
Soon after Nargis Cyclone in 2008, FREDA had distributed emergency relief assistance to 26 villages of the project area with 14,508 rice bags, 22,000 viss of cooking oil, 20,700 viss of salt, 200 rolls of tarpaulin (91 metre rolls), 4,000 bottles of drinking water, 200 T-shirts and some medicine during May to December 2008.
Under the "Food security-related relief and rehabilitation project after Cyclone Nargis, Myanmar", a total of 5,350 baskets of paddy seeds, 25 power tillers and 5,902 gallons of diesel were distributed during the period from June to November 2008 in 6 villages, in Bogale Township, Phaypon district, Ayeyarwady Delta.
Under the project of "Rehabilitation and disaster preparedness in Nargis affected area of Myanmar through sustainable landuse and renewable energy", about 42,000 grafted fruit trees seedlings were distributed to assist the livelihood security of the Nargis-hit communities and about 16 ha (40 acres) of wind-break forest were established in some villages close to the seashore. In addition, renewable energy like, solar energy, wind energy and wood/rice husk gasification were introduced in some villages as the pilot feasibility studies.
After Cyclone Nargis, the majority of the people in the cyclone-affected areas have to stay in the temporary bamboo huts and tents. Hence there was the need of permanent wooden houses and cyclone shelters in case of occurrence of natural disaster in future. Based on the population density and vulnerability of natural disaster, 4 school-cum-cyclone shelters (SCCS) were constructed in Tebinseik, OkphoKwinchaung, Kuntheechaung and Kontanpauk villages. Similarly about 500 houses were also constructed in Kontanpauk, Padekaw and HtawPaing (ShwePyi Aye) villages in 2009-10 under the "Rehabilitation of Houses and construction of Cyclone Shelter in Ayeyarwady Delta" project.
In cooperation with the DiakonieKatastrophenhilfe (DKH) of Germany, FREDA has planned to implement the project "Disaster Risk Reduction and Sustainable Landuse in the Ayeyarwady Delta after the Cyclone Nargis" for 3 years starting from 1st January 2010 up to the end of December 2012. The project activities mainly include construction of smaller school-cum-cyclone shelters, formation of high ground-cum-pond, provision of school furnitures, water harvesting scheme, training courses etc.
In partnership with NEF(Nagao Natural Environment Foundation), Japan, FREDA has been supporting the outstanding scholars of local universities leading to M.Sc and Ph.D degrees in various fields related to Botany, Biology, Ecology, Environmental Science, Forestry and Zoology. Since 1998, a total of 25 M.Sc students and 40 Ph.D candidates have been awarded with NEF Scholarship support. FREDA has also awarded scholarships to outstanding undergraduate forestry students studying at the Forestry University at Yezin and also stipends to promising high school graduates who are financially handicapped to study forestry at the University. So far a total of 61 undergraduates in forestry have been awarded scholarships and stipends since 1999 academic year. Support is also given to the outstanding students of the Myanmar Forest School at PyinOoLwin every year. Support to students in the academic field of environmental science is one of the avenues that FREDA is promoting jointly with NEF of Japan for increased awareness, motivation and experience of the younger generation, contributing towards effective conservation of the natural environment in Myanmar.
FREDA is also conducting applied research on aqua-forestry to fulfill the livelihood of Community Forestry Users Groups with funding from Wetlands Alliance.
18. FREDA is also launching on the fuel wood plantations in the Yangon division with appropriate first-growing fuelwood (Acacia spp.) with funding from Total Oil and Gas Company Ltd., Myanmar.
The present trend, now-a-days is "Green Economy and Green Growth" in mitigating global warming and climate change especially for developing countries. We, therefore, have to go ahead with Development on socio-economic and environmentally friendly guidelines in the near future.

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