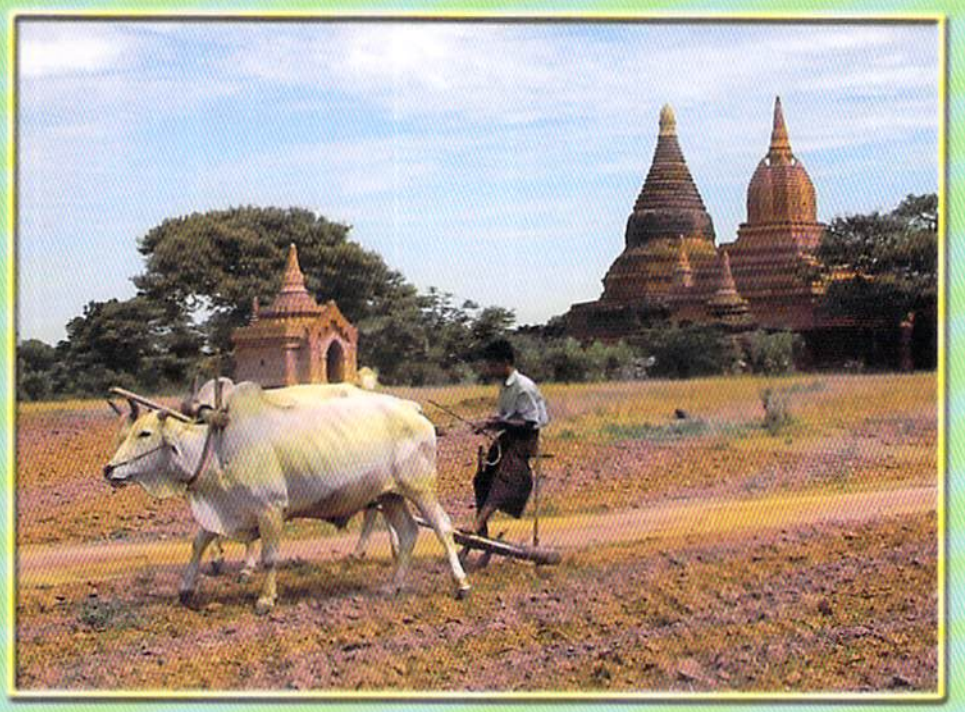
Practice-oriented Area Studies Series No.2

Integrated Study on Sustainable Agriculture and Rural Development towards Research and Education in Myanmar and Surrounding Countries

Edited by Kazuo Ando and Khin Lay Swe



November 2011

The joint project "Integrated Study on Sustainable Agriculture and Rural Development in Central Dry Zone, Myanmar"
Yezin Agricultural University (YAU), Myanmar and GCOE Program & Bay of Bangal JSPS KAKEN Project,
Center for Southeast Asian Studies (CSEAS), Kyoto University, Japan

Practice-oriented Area Studies Series No.2

Integrated Study on Sustainable Agriculture and Rural Development towards Research and Education in Myanmar and Surrounding Countries

Edited by Kazuo Ando and Khin Lay Swe

November 2011

The joint project "Integrated Study on Sustainable Agriculture and Rural Development in Central Dry Zone, Myanmar"
Yezin Agricultural University (YAU), Myanmar and
GCOE Program & Bay of Bangal JSPS KAKEN Project,
Center for Southeast Asian Studies (CSEAS),
Kyoto University, Japan

The Practice-oriented Area Studies aim the alternative Area Studies to establish the consciousness of "ZAICHI (Locally existing)" in the researchers' mind and attitude by mutual enlightenment to collaborate with the local people conducting their "Practice" in their living areas. The Practice-oriented Area Studies Series are to publish the research outcome on the basis of these researchers' consciousness.

Kazuo Ando
Coordinator of Practice-oriented Area Studies Series

First Edition
November 2011
300 copies

Published by

Yezin Agricultural University, Yezin - Naypyitaw, Myanmar

Tel: 95-67-41614. Fax: 95-67- 416517
E-mail: prorector-ac-yau@cybertech.net.mm
Distributor for Bangladesh and other countries:
Rubi Enterprise
P.O. Box 5247 (New Market)
Dhaka-1205
Bangladesh.
Tel.: 880-2-01715010058
Fax: 880-2-8624571
E-Mail: enquire@rubibook.com, rubie@dhaka.net
Web Site: http://www.rubibook.com

ISBN: 978 - 4-9016689-0-3

Cover photo: Land Preparation by Tun, Traditional Harrow of Myanmar, in Bagan (Photo by Kazuo Ando, July 23, 2006)

CONTENTS

Editorial Committee

Editors' Note : This book has been prepared as the proceeding of the International Workshop namely "Integrated Study on Sustainable Agriculture and Rural Development towards Research and Education" on 15-16 January, 2011, at Yezin Agricultural University. Some papers were unable to submit. The papers appeared in this book were improved by the comments from the participants of the workshop. Necessary and minimum editing was done by the editors.

PREFACE

According to the FAO Food Outlook Report in 2010, global cereal stocks are forecast to decline sharply and the report makes a strong call for production. With the tightening of the world food supply and demand situation, we have to increase agricultural production for the medium and long term perspectives in a sustainable way. The Myanmar farmers, especially those living in dry zone areas for centuries must have rich traditional knowledge and technologies to boost their agricultural production under the hash climates and unfavorable agro-ecological setting. It is, therefore, worthy to study the local knowledge and traditional agriculture of these farmers and to utilize these in the higher research and education.

In this regard, an international workshop on "Sustainable Agriculture and Rural Development towards Research and Education" jointly organized by the Yezin Agricultural University (YAU) and the Center for Southeast Asian Studies (CSEAS), Kyoto University, Japan was successfully held at the YAU, Yezin-Naypyitaw on 15- 16 January, 2011. It was funded by the Global COE Project, CSEAS under Japan Society for Promoting Science (JSPS), and JSPS KAKEN Project, namely "International Networking Project to Cope with Natural Hazards on the Periphery of Bengal Bay". The researchers and scientists from Lao PDR, Bangladesh, Japan and Myanmar attended the 2-day workshop and enjoyed a field study tour to the project areas. The researchers and scientists from the Department of Agricultural Planning, Department of Agricultural Research, Myanma Agriculture Service, Yezin Agricultural University under the Ministry of Agriculture and Irrigation and NGOs actively participated in the workshop. From the presentations at the workshop, valuable information, knowledge and experiences were shared among the participants. It brought significant outputs and new initiatives for cooperation in area study research within the region.

As the second phase of the Myanmar Field Station Program, CSEAS and Graduate School of Asia and Africa Area Studies (ASAFAS), Kyoto University started the collaboration with Yezin Agricultural University since 2008 for the joint area study on the multi-disciplinary field work at the dry zone of central Myanmar, namely Yamethin and Nyaung-U Townships. Under this program, a holistic study was conducted on the existing agricultural systems and rural development through cropping systems, farming systems and agro-ecosystem approaches.

This book has been designated to share the findings of the field study research among the researchers home and abroad particularly in relation to the information on existing farming

systems in the dry zone areas and the other countries' experience. This documentation will also function as a base line study for the development of sustainable agricultural production technology and reference material for study and education in the higher research and educational organizations.

We would like to request the participants here to try to set up the holistic approaches in agricultural research and education, paying attention to farming systems research & extension, agro-ecology, people participating rural development and local traditional culture. We also hope the readers of this book are interested in re-evaluation of the sustainable agricultural knowledge obtained from the farmers and local communities. Let us share experiences internationally and learn each other for sustainable development.

Last but not least, our heartfelt thankfulness must go to the authorities of Yezin Agricultural University, Department of Agricultural Planning, Department of Agricultural Research in Myanmar and the G-COE Project & Bay of Bengal JSPS KAKEN Project, CSEAS, Kyoto University for their kind collaboration and support to the workshop.

The field station program in Myanmar and surrounding countries in Asia will be continued to develop the new concept of agricultural research and education from the views of Area Studies.

Khin Lay Swe and Kazuo Ando
Co-coordinators of the workshop
The editorial committee of the proceeding of the workshop

International Workshop on "Integrated Study on Sustainable Agriculture and Rural Development towards Research and Education"

WORKSHOP PROGRAM

Program (15 January 2011)	
08:30 -09:00	Registration
09:00-09:10	Opening speech by Director General, DAP
09:10-09:20	Welcome speech by Rector
09:20-09:30	Key Note Speech "Let's share experiences internationally and learn each other for sustainable development" by Dr. Kazuo Ando CSEAS, Kyoto University, Japan
09:30-10:00	**Coffee Break**
	Day 1. Section1
10:00-10:30	Vermicompost based potting mixture on growth and yield of hot pepper by Htwe Min Thant, Than Than Nu, Maung Maung Thein and Khin San Wai, DAR, Myanmar
10:30-11:00	Community forestry in dry zone by U Win Myo Thu, MD-Ecodev, Myanmar
11:00-11:30	Improving water saving technology under water-limited condition by Dr. Khin Mar Htay, Tin Tin Myint, and Mar Mar Myint, DAR, Myanmar
11:30-12:00	Sustainable Agriculture Development in Bangladesh: critical ecological issues and choice of technology by Dr. Muhammad Salim, Bangladesh Agriculture University (BAU), Bangladesh
12:00-13:00	**Lunch Break**
	Section 2
13:00-13:30	The wild life of paddy fields in Kachin State, Myanmar by Dr. Nobuhiro Ohnishi, Kyoto Gakuen University, Japan
13:30-14:00	Sustainable on fishway design at center LAO PDR by Oudom Phonekhampheng, National University of Lao, Lao PDR
14:00-14:30	Study on past and current farming systems in Le Pyin Thar village, Yemethin Township by Dr. Theingi Myint, YAU, Myanmar

14:30-14:50	**Coffee Break**
	Section 3
14:50-15:20	Sustainability of diversified farming in Yamethin by Dr. Khin Oo and May Thuzar Moe, YAU, Myanmar
15:20-15:50	Collection and conservation of plant genetic resources in dry zone areas of Myanmar by Min San Thein, Yi Yi Myint, Khin San Wai and Khin Soe, DAR, Myanmar
15:50:16:20	Climate change and preparedness at the village level in costal areas: A situational study by Dr. Swapan Kumar Dasgupta, Director, Bangladesh Academy for Rural Development (BARD), Bangladesh
16:20	**Poster Section**
	1. Agricultural and industrial development perspective of two village tracts in Kyaukse Township by Dr. Saw Pyone Naing, Pro- Rector, Mandalay University, Myanmar
	2. Retail shops development in Meiktila Township by Dr. Saw Pyone Naing, Pro-Rector, Mandalay University and Daw Moe Moe Khaing, Assistant Lecturer, Mohnyin Degree College, Kachin State, Myanmar
	3. Structure and functions of a river bank periodic market in Darrang District of Assam, India by Nityananda Deka, A.K.Bhagabati (Guahahti University, India), Koichi Usami (Nagoya University) and Kazuo Ando, (CSEAS Kyoto University, Japan)
	4. Flood policy and people's participation in Bangladesh by Dr. Haruo Uchida (Shikoku Research Center) and Kazuo Ando, (CSEAS Kyoto University, Japan)

	Program of Second Day (16 January 2011)
	Day 2. Section 1
10:00-10:30	Land use history of swidden cultivation and forest vegetation change around Karen village in the Bago mountains, Myanmar by Dr. Reiji Suziki, ISS & CSEAS, Kyoto University
10:30-11:00	Environmental images of rural people in the dry zone, Myanmar : Case study on Popa village, Kyaukpadung Township by Dr. Saw Pyone Naing, Pro-Rector, Mandalay University, Myanmar
11:00-11:30	Sustainable agriculture and rural development activities in Myanmar by Daw Myat Thuzar Thein, DAP, Myanmar
11:30-12:00	Sustainable agriculture and rural development CDZ Area by Htin Aung Shein, MAS, Myanmar
12:00-13:00	**Lunch break**
	Day 2. Section 2
13:00-13:30	Farmers' cropping technologies to cope with dry climate, central Myanmar: A case study in Yamethin Township by Dr. Kazuo Ando Kyoto University, Japan and Lay Lay Khaing, YAU, Myanmar
13:30-14:00	Impact of crop diversification on income generation of rice-based farming systems in irrigated areas of Myanmar by Dr. Thanda Kyi, DAP, Myanmar
14:00-14:30	Impact of climate change on crop production in dry zone Myanmar: A case study in Phyauk-Seik-Pin village, Nyaung-U Township by Lay Lay Khaing and Dr. Khin Lay Swe, YAU, Myanmar
14:30-14:50	**Coffee Break**
	Day 2. Section 3
14:50-15:20	Horticulture production and rural development by Dr. San San Yi, MAS, Myanmar
15:20-15:40	General discussion by Dr. Udome Phonekhampheng, Dean, Faculty of Agriculture, University of Laos
15:40 -16:00	Closing Speech by Dr. Myint Thaung, Rector, YAU, Myanmar

KEYNOTE SPEECH

Let us share experiences internationally and learn each other for sustainable development

Kazuo Ando[1]

Mengalaba, Good Morning

All the distinguished Guests, especially U Than Aye Director General, Department of Agricultural Planning, U Khin Soe, Director General, Department of Agricultural Research and Dr. Myint Thaung, Rector of Yezin Agricultural University, Dr.Aung Kyi, Pro Rector, Yezin Agricultural University and participants. Thank you for your kind attending the international workshop.

Ladies and Gentlemen, first of all, I would like to express a heartfelt thankfulness to the authorities of the Yezin Agricultural University and Department of Agricultural Planning to agree with us to hold "International Workshop on Sustainable Agriculture and Rural Development towards Research and Education "which is jointly organized by Yezin Agricultural University and the Center for Southeast Asian Studies, Kyoto University, supported by the following two projects of Japan Society for Promoting Society(JSPS), namely Myanmar Field Station Program, Kyoto University supported by Global COE Project, CSEAS and KAKEN Project, "International Networking Project to Cope with Natural Hazards on the Periphery of Bengal Bay ", headed by me.

The Myanmar Field Station Program, Kyoto University has initially started in collaboration with SEAMEO-CHAT and CSEAS, Kyoto University since 2003 to introduce the joint study methodology of the area study or the multi-disciplinary field work to learn the local people wisdom and learn each other among the participant scholars of a multi-disciplinary team. The station has been located at the SEAMEO-CHAT office in Yangon and the joint study team consisted of the Ph.D. candidates of Yangon University and senior scholars from SEAMEO-CHAT, Yangon University and University Historical Research Center. The study has been conducted by the integrated disciplinary approach consisted of history, geography, zoology, botany and other disciplines, agricultural science etc. The study site was the villages in Maubin District, Ayeyarwady Delta, focusing on livelihood, natural resources and rural development with historical perspective. The internal-workshop of this project was held in August 24-25, 2006 at the SEMEO-CHAT, titled "Review Meeting on Rural life and Local Knowledge in Ma-U-bin District, Ayeyarwady Delta". Prof. Khin Lay Swe was individually invited at the workshop to present her paper about the traditional mixed cropping of rice and black gram. She was working

1.Center for Southeast Asian Studies, Kyoto University

with me when she was a visiting research fellow of the CSEAS, Kyoto University in 2005. On the basis of this workshop, we would like to set the second phase joint study at the dry zone of the central Myanmar, the home of Burmese culture. The YAU was requested to take responsibility to implement the field station program. The joint study sites were selected in Yamethin and Nyaung-U and their surroundings. The scholars and MS students of YAU took main role for the joint study and the staff from DAR and DAP sometime participated in the field work. The scholars and Ph.D. candidates of the department of Geography, Mandalay University also individually participated in the study program.

The new activity of the second phase of the field station focuses on mutual learning not only within Myanmar but also the foreign countries, where the field station or joint study program are implemented. The aim of this activity is to share the experience to open the international view for the role of research and education with emphasis of the sustainable development. For this purpose, we had the series of workshops in Japan, Assam, Laos and recently in Bangladesh.

The counterparts of Myanmar, Laos, Indonesia and Bangladesh were invited for each workshop and study tour to share the experience and exchange the opinion to learn each other. The international workshop in Laos, Bangladesh and this time Myanmar are particularly focusing the research and education in the university, how to learn the local knowledge of the farmers or traditional agriculture and to utilize these in the higher research and education, because the sustainable development has been well achieved in the traditional agriculture particularly in the countries such as Laos, Bangladesh and Myanmar. The counterparts who participated the study tour in rural Japan well understood that the sustainability is disappearing in agriculture and rural communities in Japan as a result of establishing modern agriculture and life systems introduced with ignoring or non-respecting the local knowledge or systems fostered by the experiences and wisdoms of the villagers. In Japan, de-population and abundant rice field problems occur in rural area at large extent. Frankly say, we Japanese scholars and officials seemingly have tried to change the farmers without proper evaluating their ways rather than learn the good points of their ways in Japan. As a result of this, sustainability of agriculture and rural communities has rapidly disappeared. Furthermore, the less interest in learning from the farmers by Japanese scholars and officials concerning in agriculture and rural development is well illustrated in the fact that, so far I know, there is no institutionalized setup of department of Agricultural extension, Farming system, Cropping system, Rural development, Agro-ecosystems or Agro-ecology in Agricultural Universities or Faculties of Agriculture in Japan. The Agronomy Department, most necessary agricultural science for the farmers, has disappeared from Japan and even nowadays the agricultural faculties of some universities have tried to remove the agriculture from their name of the faculty.

Ladies and Gentlemen, this is an aspect of reality appeared in the agriculture research and the education in Japan. However, we, some of scholars and officials concerning agricultural research and education in Japan to hope re-vitalization of agriculture and rural community, sincerely want to learn from the experience and the reality of our Asian friend countries where the villagers live

with healthy smile and rural communities are rich in wisdom and knowledge for realizing sustainability in their livelihood and culture. The participants here are kindly requested to understand that the relationship between developing countries and developed countries have already changed from the view point of sustainable development. Top is last and last is top. We, people living in the countries such as Japan, have a lot to learn from Myanmar.

Anyway, firstly, I came to YAU in Jan. 1997. 14 years has already passed and that time, I met U Soe Myint, the specialist of cropping system and farming system, CARI (now DAR) to learn the research situation of Cropping systems, Farming systems, Agro-ecosystems and Rural Development. From that day up to now, I have been surprised at the well maintained agro-ecological balanced cropping systems and life style in rural Myanmar. The contradiction of modern agricultural systems and rural development has not appeared in Myanmar at large extent since I came to Myanmar. Why was I interested in this issue in 1997? Because, when I was working in rural Bangladesh as a Japan Overseas Cooperation Volunteers (JOCV) and a Japan Internationl Cooperation Agency (JICA) Expert in 1980 and 1990s, the contradiction of modern agricultural systems appeared clearly and thus, the agricultural scientists and the practitioners have known the limitation of the modernization in agriculture by applying the modern component technologies, which does not pay attention to the holistic efficiency of the farming or agro-ecosystems. In 1980s and 1990s, in the developing countries such as Bangladesh, India and Thailand, the agricultural scientists and the practitioners tried to learn the holistic consideration of agricultural technologies and systems from the farmers' experience through cropping systems, farming systems and agro-ecosystem approaches to overcome the contradiction of the modern agriculture and rural development.

In Bangladesh, there was advantage in agriculture and rural development in research and higher education at the university level. The action research and extension through the department of agricultural extension & the extension laboratory areas of the research institutes and the agricultural university such as Bangladesh Rural Development Academy (BARD) and Bangladesh Agricultural University (BAU) has been established since 1960s, it was much advanced setup in the world. The laboratory area or the extension area of the research and the university besides the agricultural department are very unique in the world and this approach tries to encourage the scholars, students and officials to learn from and stand with the small farmers, who are most large population in the rural area in Bangladesh. Still, it is common sense among agriculturists in the world that there is no way to realize sustainable development in the country such as Bangladesh, Laos and Myanmar without realizing uplift of the life of the small farmers.

Ladies and Gentlemen, as a conclusion of my keynote speech, I would like to request the high officials of the research and education in the institutes of Myanmar to perceive an advantage the traditional agriculture and the rural community in Myanmar and to learn from the advantage of their livelihoods and production systems so that you can find the own Myanmar way for sustainable development. This is essential feeling of responsibility against the world. The world is waiting for your creativeness to open the new road of agricultural and rural development on the basis of

traditional culture and systems in Myanmar, which have mostly disappeared from the developed countries such as Japan.

Up to now, in Myanmar, it is not seriously required the holistic approach for research and education of agriculture and rural development, because the contradiction of the modern agriculture and the sustainable development has not appeared clearly, yet. However, according to my own field experience in Myanmar, such an era will come sooner in accordance with the rapid economic development. Therefore, I would like to request the participants here to try to set up the holistic approaches in agricultural research and education, paying attention to farming systems research & extension, agro-ecology, people participating rural development and local traditional culture.

Ladies and Gentlemen, I believe that Myanmar has the most advantage and possibility to create an alternative way for sustainable development because of her rich tradition and cultural background, which nobody can find in the world. I am very proud of holding the workshop in such a country of Myanmar and thankful to Destiny of Land of Buddha. It is not well known to the outsiders for Bangladesh that historically and traditionally, Bangladesh culture is deeply rooted in the Buddhism from the ancient period. Laos is too. Therefore, I believe that the participants from Bangladesh and Laos are surely interested in the Myanmar culture based on the Buddhism. After workshop, we are planning to visit the villages of the dry zone and Buddhism archeological site, Bagan for our field study. The participants from Bangladesh, Laos and Japan can get lessons about the heart of Myanmar.

Last but not least, I must express my deep thankfulness to my counterparts, Prof. Khin Lay Swe, other colleagues and students of YAU, without their sincere volunteer spirits, we cannot hold the workshop, and also to Prof. Salim, Dr. Swapan from Bangladesh and Prof. Uduom from Laos for their never give-up sprit to getting the visa, and kind cooperation of DAP, DAR and Mandalay University personnel to present the papers in the workshop and, especially to DAP officials their administrational collaboration to arrange the visa to us.

Let us share experiences internationally and learn each other for sustainable development openly and frankly, let us enjoy the workshop as friends and for future continuation of our network.

Thank you very much for listening

VERMICOMPOST BASED POTTING MIXTURES ON GROWTH AND YIELD OF HOT PEPPER (*Capsicum* spp.)

Htwe Min Thant[1], Than Than Nu[1], Maung Maung Thein[1] and Khin San Wai[1]

Abstract

Due to the conventional agricultural production for several decades in Myanmar, with the inbalanced and rempant use of chemical fetilizers, many agricultural soils are declining in productivity. It is well recognized that adoption of sustainable agriculutre can reverse this trend and increase the environmental protection. Vermicomposts are finely divided peat-like materials with high porosity, aeration, drainage, and water holding capacity. The experimental results showed that vermicompost application provided the better performance in agronomic traits of hot pepper than cowdung manure and garden composts. It stimulated root growth, facilitating nutrient absorption and thereby favoring higher yield than other composts.

Key Words : Vermicompost, soil degradation, hot pepper, growth and yield

Background

Pepper (*Capsicum spp.*) is the world's second most important solanaceous vegetable after tomato (AVRDC 1997). It is rich in vitamins A, B1, B2, B3 and C. Both hot and sweet peppers contain more vitamin C than any other vegetables (Choudhury 1967 and Tindall 1968). Pepper is originated in Mexico, Central and South America (Walter 1986).

Environmental degradation is a major threat confronting the world, and the rampant use of chemical fertilizers contributes largely to the deterioration of the environment through depletion of fossil fuels, generation of CO_2 and contamination of water resources. Due to imbalanced use of fertilizers, it leads to loss of soil fertility that has adversely impacted agricultural productivity and causes soil degradation. Now, there is a growing realization that the adoption of ecological and sustainable farming practices can only reverse the declining trend in the global productivity and increase the environment protection (Nagavallemma *et al.* 2004).

Composting, generally defined as the biological aerobic transformation of an organic byproduct into a different organic product that can be added to the soil without detrimental effects on crop growth, has been indicated as the most adequate method for pre-treating and managing organic wastes (Godden *et al.* 1986). The conventional and most traditional method of composting consists of an accelerated biooxydation of the organic matter as it passes through a thermophilic stage (45°C to 65°C) where microorganisms liberate heat, carbon dioxide and water (Dominguez *et al.* 1997). However, in recent years, researchers have become progressively interested in using another related biological process for stabilizing organic wastes, which does not include a thermophilic stage, but involves the use of earthworms for breaking down and stabilizing the organic wastes. The ability of some earthworms to consume a wide range of organic residues such as sewage sludge, animal wastes, crop residues, and industrial refuse has been fully established.

1. Department of Agricultural Research, Yezin-Naypyitaw

Vermicomposting is a simple biotechnological process of composting, in which certain species of earthworms are used to enhance the process of waste conversion and produce a better end product. Earthworms consume various organic wastes and reduce the volume by 40-60 % (George 2001). Vermicompost contains not only worm castings, but also bedding materials and organic wastes at various stages of decomposition. Secretions in the intestinal tract of earthworms make nutrients more concentrated and available for plant uptake, including micronutrients (George 2001). Vermicomposts are finely divided peat-like materials with high porosity, aeration, drainage, and water-holding capacity (Edwards and Burrows 1988).

Thus, it urgently needs to apply the vermicompost instead of chemical fertilizers for sustainable vegetables production.

Objectives

1. To determine the effects of different ratios of vermicompost on the yield and agronomic traits of hot pepper

2. To compare the effects of vermicompost, cowdung manure and garden compost on hot pepper production

Materials and Methods

Location	-	Fruit Research Field No. (5), Horticulture Section, DAR
Duration	-	May, 2010 to November, 2010
Experimental Design	-	(6 x 7) RCBD
Variety	-	Indian Pendent Hot Pepper
Pot/container size	-	(48 Length x 40 Width x 35 Diameter) cm³ or 20 kg/volume

Field Layout

Rep I	Rep II	Rep III	Rep IV	Rep V	Rep VI	Rep VII
T_6	T_4	T_2	T_5	T_1	T_6	T_3
T_5	T_1	T_6	T_4	T_3	T_2	T_1
T_4	T_2	T_3	T_1	T_4	T_5	T_4
T_3	T_6	T_5	T_6	T_5	T_1	T_5
T_2	T_3	T_4	T_2	T_6	T_3	T_2
T_1	T_5	T_1	T_3	T_2	T_4	T_6

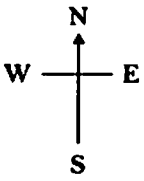


Plate 1. Vermicompost pot experiment layout

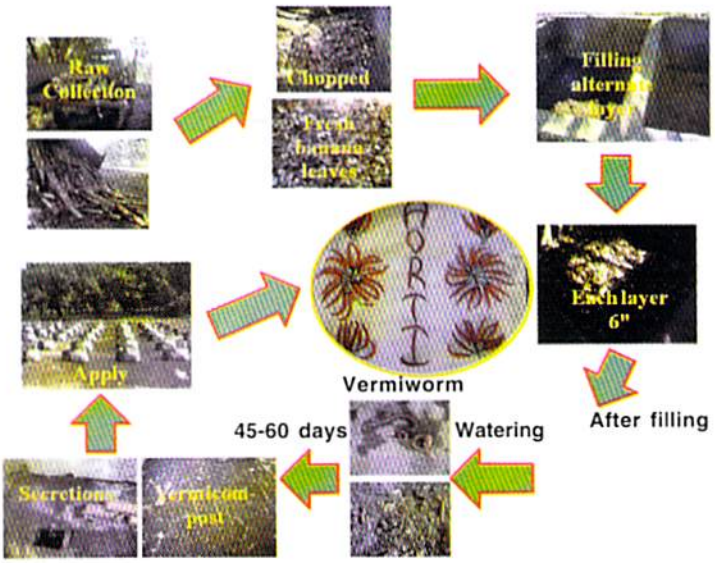


Plate 2. The process of vermiculture to application or utilization of vermicompost on hot pepper production leading to sustainable agriculture

Treatments

Treatments	Vermicompost (VC) (%)	Cowdung Manure (CM) (%)	Garden Compost (GC) (%)	Sand (%)	Rice Husk Charcoal (%)
T_1	20	30	-	12	38
T_2	30	20	-	12	38
T_3	40	10	-	12	38
T_4	50	-	-	12	38
T_5	-	50	-	12	38
T_6	-	-	50	12	38

Data collection

(1) Initial plant height (cm)
(2) Plant height at 14 days interval (cm)
(3) Plant height at harvest (cm)
(4) Days to first flowering
(5) Days to first harvest (ripening)
(6) Number of fruits per plant
(7) Fruit weight (g) per plant

Results and Discussion

The analysis of variance showed significant differences among the treatment for all of the traits except initial plant height and plant height at harvest (Plate 2, Figure 1 and Table 1).

Among the treatments, T_1 (50 % VC) expressed the taller plant height from 14 DAT to 84 DAT than other treatments (Plate 2, Table 1 and Figure 1). Similar result was obtained by Prabha *et al.* (2007): application of vermicompost had a significant effect on plant height on chilli (*Capsicum annum*) with a maximum height of 75 cm. This may be due to effect of N which was enriched in vermicompost, vermicompost stimulated root growth, facilitating nutrient absorption and thereby favouring higher yield than other compost.

In this study, significant increases in number of fruits per plant and fruit weight per plant were observed in vermicompost in comparison with cowdung manure and garden compost treatments. Similar results have been obtained by Karmegam *et al.* (1999), the growth and yield of mungbean was also significantly higher with vermicompost application than other composts. In addition, Nagavallemma *et al.* (2004) reported that application of vermicompost at 5 t ha^{-1} significantly increased yield of tomato.

Number of fruit per plant of T_4 (50% VC) (105.29) was significantly higher than other treatments. Moreover, T_3 (40% VC + 10 % CM) gave the second maximum number of fruit per plant (98.57) among the treatments. The minimum number of fruit per plant were observed in T_5 (50% CM) (50.88) and T_6 (50% GC) (54.71) (Table 1).

According to the fruit weight per plant, the treatments which applied different ratio of vermicomposts were shown larger fruit weight than other two treatments such as cowdung manure and garden compost treatments. Among them, highest fruit weight per plant was observed in T_4 (50% VC) (271.87 g) followed by T_3 (40% VC + 10 % CM) (217.34 g) (Table 1).

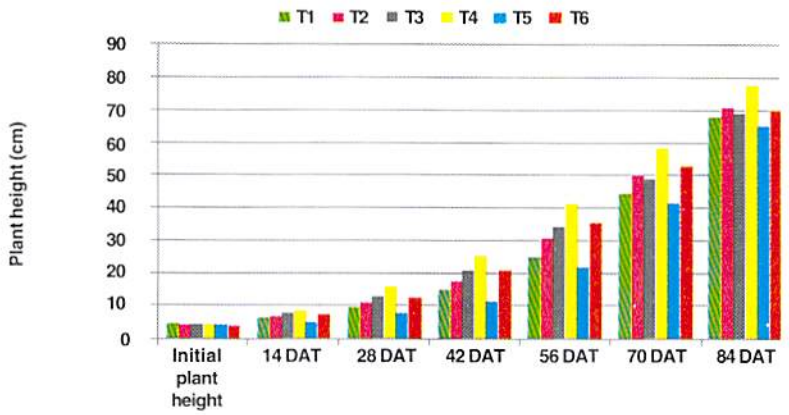


Figure 1. Plant height (cm) for each treatment at 14 day-interval during the growing season

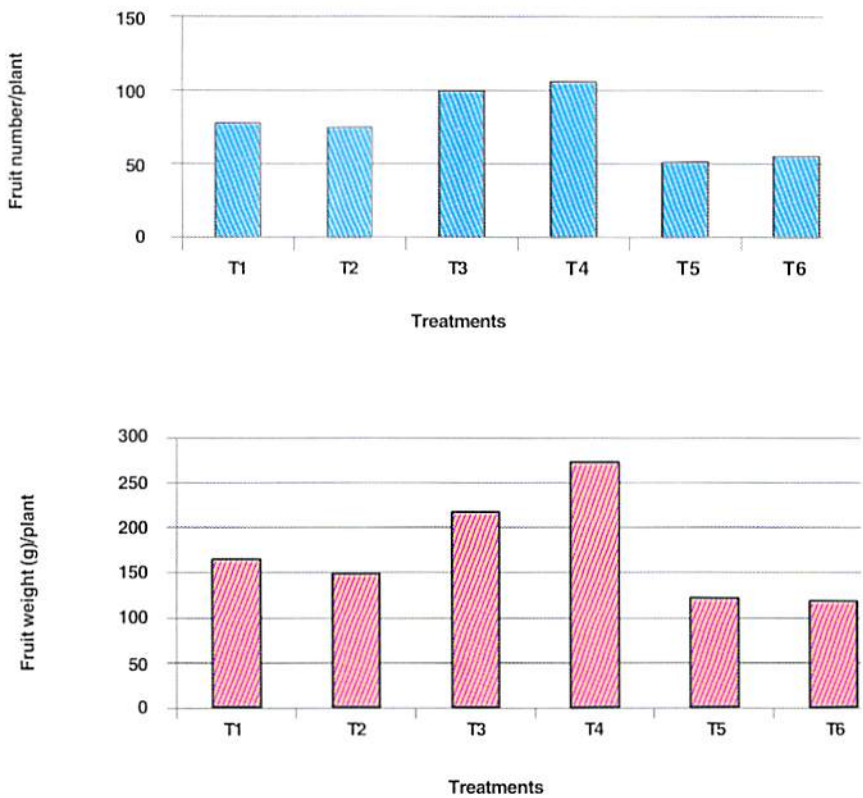


Figure 2. Effects of different rates of vermicomposts and other composts on (a) Fruit number/plant and (b) Fruit weight (g)/plant

Table 1. Effects of different rates of vermicomposts and other composts on agronomic traits and yield of hot pepper

Treatments	Initial plant height (cm)	14 DAT (cm)	28 DAT (cm)	42 DAT (cm)	56 DAT (cm)	70 DAT (cm)	PH at harvest (84 DAT) (cm)	Days to first flowering	Days to first harvest (ripening)	Fruit No./plt	Fruit Weight (g)/plt
T1	4.64	6.79	9.96	15.21	25.47	44.57	68.00	68	129	77.43	164.20
T2	4.36	7.26	11.60	17.90	31.29	50.29	71.00	67	129	74.29	148.33
T3	4.43	7.99	13.33	20.86	34.54	49.00	69.00	63	120	98.57	217.34
T4	4.36	8.94	15.91	25.30	41.57	58.43	77.86	61	120	105.29	271.87
T5	4.40	5.21	8.26	11.91	22.06	41.86	65.71	69	129	50.86	121.84
T6	4.21	7.83	12.91	20.94	35.94	53.14	69.71	69	129	54.71	119.01
F-test	ns	**	**	**	**	**	ns	**	**	*	**
CV%	25.80	14.00	17.60	17.00	21.60	16.90	15.40	2.50	1.30	46.90	45.90
$LSD_{(0.05)}$	6.77	1.12	2.31	3.46	7.51	9.13	11.77	1.80	1.84	39.38	87.10

Conclusion

According to the results, it can be concluded that application of different ratios of vermicompost treatments were significantly effective on hot pepper agronomic traits than cowdung manure and garden compost treatments. Among the vermicompost treatments, T_1 indicated the highest in plant height at harvest, earliest in days to first flowering and first harvest and increased in number of fruits and fruit weight per plant. T_3 treatment showed relatively increase in number of fruits and fruit weight per plant compared to T_4 treatment.

Acknowledgement

I would like to express our sincere thanks to U Khin Soe, Director-General, U Hla Tin, Director (Retd.), Industrial and Horticultural Crops Division, DAR, for their permission and encouragement to initiate and conduct this experiment. We greatly appreciate to Section Head and Staff from Soil Science Section and Water Utilization Research Section, DAR and Plant Protection Division, Myanma Agriculture Service, Yangon for analyzing the composts and fresh fruits for this experiment. Finally, deep gratitude is due to our senior and junior researchers at Horticulture Section, DAR who were participating in this experiment and everything they did for us.

References

AVRDC (Asian Vegetable Research & Development Center). 1997. Training Report 1996. AVRDC. Shanhua, Tainan, Taiwan. 119-123.

Choudhury, B. 1967. Vegetables. New Dehli, India: National Book Trust, Co. 58-60.

Dominguez, J., C. A. Edwards, and S. Subler. 1997. A comparison of vermicomposting and composting. BioCycle 38, 57-59.

Edwards, C. A., and I. Burrows. 1988. The potential of earthworm composts as plant growth media. In: Edwards, C. A., Neuhauser, E. (eds.) Earthworms in Waste and Environmental Management. SPB Academic Press, The Hauge, The Netherlands, 21-32.

George, W. D. 2001. Vermicomposting. Cooperative Extension Service, College of Agriculture and Home Economics, New Mexico State University.

Godden, B., M. J. Penninckx, and C. Castille. 1986. On the use of biological and chemical indexes for determining agricultural compost maturity: extension to the field scale. Agricultural Wastes 15, 169-178.

Karmegam, N., K. Alagermalai, K. and T. Daniel. 1999. Effect of vermicompost on the growth and yield of greengram (*Phaseolus aureus* Rob.) Tropical Agriculture 76(2): 143-146.

Nagavallemma, K. P., S. P. Wani, L. Stephane, V. V. Padmaja, C. Vineela, R. M. Babu and K. L. Sahrawat. 2004. Vermicomposting: Recycling wastes into valuable organic fertilizer. Global Theme on Agroecosystem Report No. 8. Patancheru 502324, Andhra Pradesh, India: ICRISAT. 20.

Prabha, K. P., Y. L. Loretta and R. K. Usha. 2007. An experimental study of vermin-biowaste composting for agricultural soil improvement. Science Direct, Bioresource Technology, Available online at www.sciencedirect.com.

Tindall, D. 1968. Commercial vegetable growing London: Oxford University Press. 201-207.

Walter, H. 1986. Pepper Breeding. *In:* Breeding vegetable crops 1986. West Port, Connecticut: AVI Publishing Co. 690.

THE RESPONSE OF SOME AEROBIC RICE VARIETIES TO DIFFERENT THRESHOLD LEVELS OF AWD CONDITIONS

Khin Mar Htay[1], Kyaw Mying[2], Aung Kyaw Thu[3], Tin Tin Myint[4] and Mar Mar Myint[5]

Abstract

Aerobic rice systems are still in research and development phase in Myanmar. Aerobic rice is a water saving rice production system for water-scarce environments with favourable irrigation management strategies and practices at farm level and supplementary irrigation is applied as necessary. In the dry season of 2010, water by variety experiment was set up at DAR, Yezin, Nay Pyi Taw, Myanmar, to explore water and variety in aerobic rice system. Sixteen treatment combinations comprised of three threshold levels of Alternate Wetting and Drying (AWD) conditions (irrigated at 5 cm water depth when the water level reached 15 cm, 25 cm, 30 cm each below the soil surface and continuous flooding (CF) with 3 to 10 cm water depth throughout the growing period) and four aerobic rice varieties (IR 77080-B-34-3, WAB 880-SG-6, UPLRi 7 and Aerobic 1) were assigned in a split plot design replicated four times. Wherein, method of irrigation was relegated in the main plots and varieties were assigned to the sub-plots. Although there were no significant differences in yield and growth attributes among the methods of irrigation, tested, AWD can save irrigation water by 49% to 59% as compared to CF. Total water use among the different threshold levels of AWD conditions were not much different, irrigation frequencies, however, were somewhat different. The shorter the irrigation interval, more frequent irrigation was needed if re-irrigation was done only when the water level reached 15 cm below soil surface (AWD1). The longer the irrigation interval, less frequent irrigation was required if re-irrigation was done only when the water level reached 30 cm below soil surface (AWD3). The higher yield of IR 77080-B-34-3 and WAB 880-SG-6 over the other two varieties can be attributed by their heavier grain weight, higher in both biomass weight and crop growth rate (CGR). Water use efficiency responsed by variety ranged from 0.49 to 0.65 kg m-3. The interaction effect of variety and moisture regime failed to reach significant level. Further study will be needed to clarify interaction of plant growth development and moisture level in AWD condition.

Key Word: aerobic rice, moisture level, yield, water use efficiency

---

1. Assistant Research Officer, Water Utilization Research Section, Soil, Water Utilization and Agricultural Engineering Division, DAR

2,3. Junior Research Assistant, Water Utilization Research Section, Soil, Water Utilization and Agricultural Engineering Division, DAR

4. Senior Research Officer, Rice Section, Rice Division, DAR

5. Director, Soil, Water Utilization and Agricultural Engineering Division, DAR

Introduction

Climate change has emerged as one of the most crucial environmental challenges of the 21st century. Climate change adversely affects ecosystems, hydrology and water resources, food and fiber production, coastal system and human health. Many regions of Myanmar felt extremely hot weather condition and drought in many parts of the country. Rainfall was below average in those areas. During that period, water scarcity was the main problem everywhere and adversely affecting on agricultural productivity.

In Myanmar, presently there are 11.38 mha of net sown area. Paddy occupied 8.3 mha as the largest area, comprising 7 mha as monsoon rice (61% of total net sown area) and 1.3 mha as summer rice in 2009-2010. Rice cultivation which accounts for 58 % of total rice sown area is under rain-fed ecosystem whereas only 20% is cultivated as irrigated rice. Although there are abundant water resources potential, the present total water consumption in rice cultivation is generally high since rice is traditionally grown under continuous flooding in which the tremendous amount of water is used. For water saving in rice cultivation, Alternate Wetting & Drying (AWD) practice has been introduced as a water saving technology in 2004–2005 by DAR. AWD is an irrigation practice in which irrigation is done with 5 cm water depth only when the field water level reached 15 cm below the soil surface, which can save irrigation water by 18-23% of that used in CF. AWD technology highlighted the advantages of saving water with decrease in water use and increase in water productivity in rice production. In this regard, the irrigation area can be expanded with existing irrigation water availability. In the dry zone area, rice growing area was expanded with the provision of irrigation water through pump irrigation from river and underground water resources.

Tuong and Bouman (2003) estimated that about 2 million ha of Asia's dry-season irrigated rice area will suffer water shortages by 2025. One of the adaptation strategies for water shortage is the system of aerobic rice, in which adapted to mild or medium water stress are grown, under aerobic non-saturated soil conditions (Bouman et al., 2005). Therefore, in the dry zone area, AWD water saving practice with aerobic rice variety should be introduced to promote the rice productivity under water-limited condition. The present experiment was therefore, undertaken to find out efficient irrigation management with response of some aerobic rice varieties to different levels of AWD conditions.

The objectives of this experiment were:

(1) To assess the growth and yield of different aerobic rice varieties under different threshold levels of AWD conditions

(2) To identify the proper water regime for aerobic rice production

Materials and Methods

Experiment :

The water by varieties experiment was conducted in the dry season of 2010 at Rice Division, DAR, Yezin, Nay Pyi Taw, Myanmar. Experimental field was characterized by a sandy loam soil. The chemical properties of the experimental soil were pH 6.32, available N (%) 0.0061, available P_2O_5 (lb acre-1) 30.54, available K_2O (%) 0.0236, Ex. Ca (me/100 g) 3.07, and Ex. Mg (me/100 g) 0.81. Climatic data during the crop growth period from January to June in 2010, are summarized in Fig. 1 and Fig. 2. An experiment with four replicates was set up in a split plot design with the water treatment as the main plot and variety as the sub-plot. Individual sub-plot size was 6 m x 5 m. Water treatments were : irrigation to be at 5 cm water depth when the water level reached 15 cm (AWD_1), 25 cm (AWD_2), 30 cm (AWD_3) below soil srufacc, and maintained 3 to 10 cm water depth throughout the growing period (continuous flooding, CF). Irrigation treatments were started two weeks after transplanting. The field water tubes were installed in every plot to monitor the water level below the soil surface. In all AWD treatments, one week before and after flowering, water level was kept at 5 cm depth to avoid any water stress to the plants. Terminal drainage was done two weeks before the expected harvest time.

Varieties used were IR 77080-B-34-3 (V_1), WAB 880-SG-6 (V_2), UPLRi 7 (V_3) and Aerobic 1 (V_4) which were introduced from International Rice Research Institute, Philippines. A total of 127 Kg ha^{-1} N was applied with three equal splits: 33.3% at mid tillering (MT), 33.3% at panicle initiation (PI) and 33.3% at flowering (F). A total of 62 Kg ha^{-1} P_2O_5 was applied as basal at final land preparation and 41 Kg ha^{-1} K_2O was spilt into a first basal application (50%), and the second half together with the respective N spilt application at mid tillering. The field was kept weed free through the application of the herbicide, Yelaung, at transplanting and manual weeding was also done if necessary. Furadan was applied to the soil around panicle initiation to counteract suspected soil-borne pests.

Measurement :

Ground water table depth was monitored through three field water tubes which were strategically placed at the experimental site. Daily field water levels was monitored by observing the field water tubes and irrigation water input was measured from crop growth period until terminal drainage. Water use efficiency was calculated by the ratio of grain yield and total amount of water use. Daily meteorological data (such as, rainfall, sunshine hour, evapotranspiration, and minimum and maximum temperature) were collected from a small weather station near the experimental site. Grain yield was harvested from a 6 m^2 sampling area in the center of each plot and recorded at 14% moisture content. Yield components were determined at physiological maturity from 2 row sample of 1 m each located at 2 corners of the final harvest area. During the crop growth period, sequential samples were collected for biomass and leaf area index (LAI) at PI, flowering and physiological maturity (PM) stages from a composite row sample of 1 m at each site of the central final harvest area. The fresh samples were dried in an oven at 60-70^{0}C until obtaining the constant weight.

Harvest index was determined at physiological maturity from 2 rows sample of 1 m each located at 2 corners of the final harvest area. Crop growth rate (CGR) was calculated using the following equation:

$$\text{CGR (g day}^{-1}) = \frac{W_2 - W_1}{T_2 - T_1}$$

Where,
W_1 = Total dry matter at time t_1
W_2 = Total dry matter at time t_2
T_1 = Time of first observation
T_2 = Time of second observation

The Models procedure of CROP STAT, version 7.2 was used for statistical analysis, analysis of variance and mean separation through LSD.

Results and Discussion

Data on rainfall, temperature, sunshine hour and evapotranspiration at daily and monthly basis during the crop period from January 12 to June 15, 2010 are presented in Fig. 1 and Fig. 2. The total amount of rainfall during the period was 277 mm and it stated at flowering time. It was highest in May with a total of 156 mm and lowest in June with a total precipitation of 121 mm. The monthly mean minimum and maximum temperature during the cropping season ranged from 16.5 – 26.4^{0}C and 33.8 – 43.5^{0}C, respectively. The mean maximum temperature in Apirl covered the late reproductive phases of the experimental plants. The highest relative humidity was 69% in June and the lowest was 45% in February. The longest average sunshine hour occurred in Apirl (267 hrs) and the shortest in June (100 hrs). The highest evapotranspiration was recorded in Apirl (174 mm) and the lowest in February (97 mm).

Among the water regimes, grain yield ranged from 3.40 t ha^{-1} to 3.81 t ha^{-1}, and the yield trend seemed to be associated with total water use. Although grain yields among the water regimes were not significantly different, total water use in three threshold levels of AWD conditions were much lower than that of CF. AWD practice can save irrigation water by as much as 49-58 % of that used in CF. However, total water use among AWD conditions were not much different, under AWD_1, shorter interval was noticed with more irrigation frequencies and vice versa under AWD_3. In this study, grain yield significantly varied among the tested varieties (Table 1). IR 77080-B–34-3 was the highest yielder with an average of 4.03 t ha^{-1}. This was significantly higher than the yield of UPLRi 7, which had the lowest yield of 3.08 t ha^{-1}.

The independent effect of variety exhibited significant effect on the number of spikelets per panicle but not either of water regimes or their interaction. Results showed that Aerobic 1 produced the highest number of spikelets per panicle with a mean of 169 spikelets (Table 2). This was significantly higher than the spikelet production of the other varieties because of genetic variation. According to Parao (1985), some varieties may have more panicles but fewer spikelets per panicle, or vice versa.

Table (2) showed that higher percent filled grains was produced by IR 77080-B-34-3, with a mean of 67 % than WAB 880-SG-6 and UPLRi 7, with means of 64 % and 61 %, respectively. The filling of grain of the varieties under study was not encouraging since it was within the 60-70% mark including Aerobic - 1 which served as check variety. There was no response to moisture regime in terms of percent filled spikelets and no interaction effect of variety and water regime in this study.

Grains of IR 77080-B-34-3, with an average weight of 25.48 g per thousand was found to be significantly heavier than Aerobic - 1 variety (Table 2). The differences in grain weight obtained in this study reflect varietal differences. However, Yoshida (1981) stated that 1000 grain weight is a stable varietal characteristic. As to the effect of moisture regimes, there was no significant difference, and interaction failed to show significant influence on grain weight.

Table 1. Yield at 14% moisture content in the water x variety experiment in 2010 dry season

Variety	Yield (t ha^{-1})				
	AWD_1	AWD_2	AWD_3	CF	Mean
IR 77080-B-34-3	3.37	3.72	4.97	4.07	**4.03a**
WAB 880-SG-6	3.79	3.43	3.96	4.11	**3.82a**
UPLRi 7	3.28	2.99	2.49	3.55	**3.08b**
Aerobic - 1	3.18	3.77	3.53	3.53	**3.50ab**
Mean	**3.40**	**3.48**	**3.74**	**3.81**	-
F-test	Water Regime				ns
	Variety				5%
	Water Regime * Variety				ns
CV %	Water Regime				33.4
	Variety				24.1
$LSD_{0.05}$	Variety				0.62

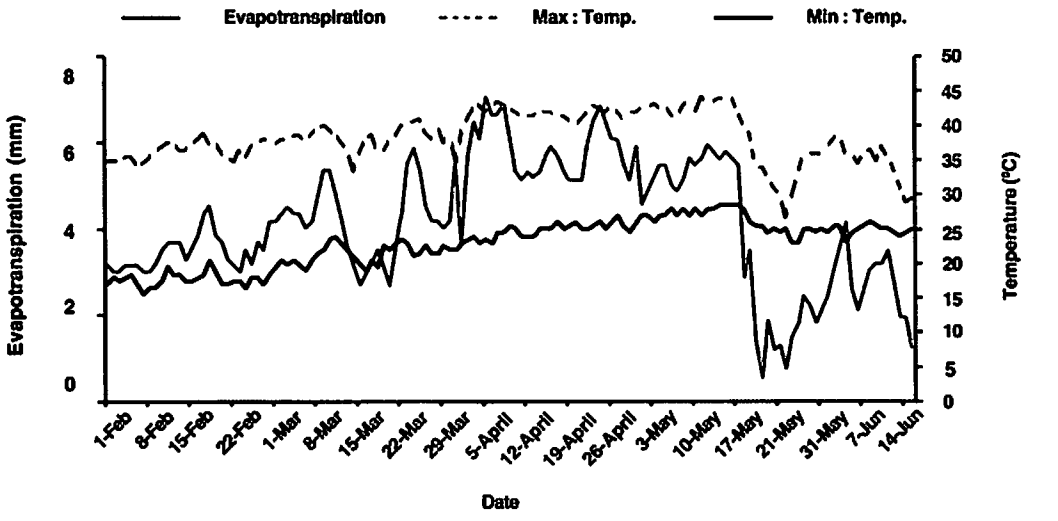


Figure 1. The meteorological conditions (evapotranspiration, maximum and minimum temperature) during the growing season

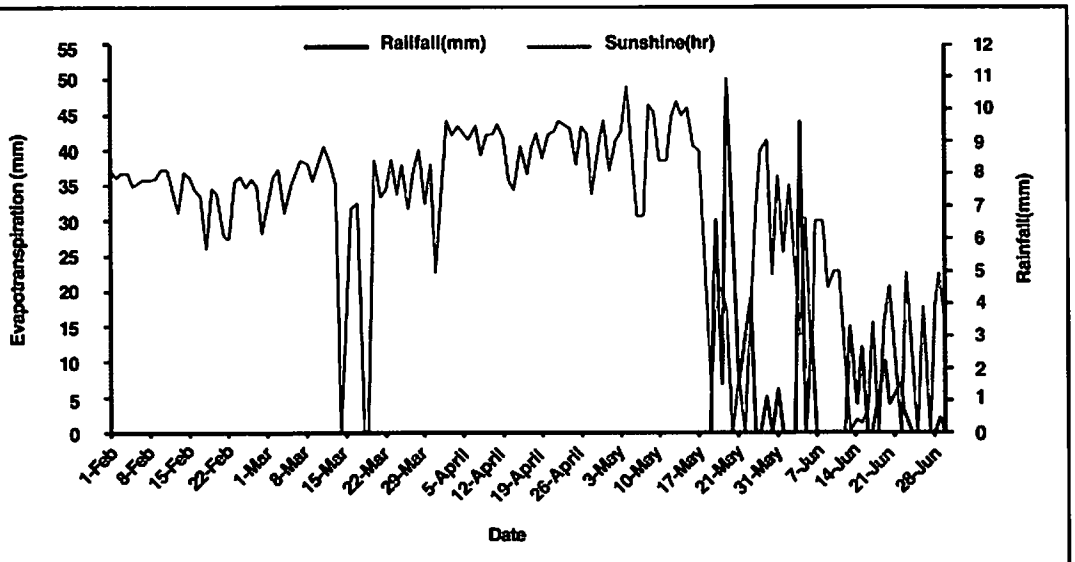


Figure 2. The meteorological conditions (sunshine hour and rainfall) during the growing season

Table 2. Yield components of rice in the water x variety experiment in 2010 dry season

Variety	Spikelets Panicle^{-1}					Filled Grains %					1000 Grain Weight (g)				
	AWD_1	AWD_2	AWD_3	AWD_4	Mean	AWD_1	AWD_2	AWD_3	AWD_4	Mean	AWD_1	AWD_2	AWD_3	AWD_4	Mean
IR 77080 -B-34-3	135	127	113	122	**124c**	65	68	67	68	**67**	25.40	25.75	25.75	25.00	**25.48a**
WAB 880 -SG-6	145	137	133	127	**136b**	69	55	66	67	**64**	24.73	24.58	24.63	24.38	**24.58b**
UPL Ri 7	115	123	112	111	**115d**	68	58	60	58	**61**	25.03	25.15	25.03	25.30	**25.13a**
Aerobic 1	160	167	174	177	**169a**	62	68	61	63	**63**	21.78	21.28	21.35	20.55	**21.24c**
Mean	**139**	**138**	**133**	**134**	-	**66**	**62**	**63**	**64**	-	**24.23**	**24.19**	**24.19**	**23.81**	-
F-test	Water Regime				ns					ns					ns
	Variety				1%					ns					1%
	Water Regime * Variety				ns					ns					ns
CV %	Water Regime				5.7					12.6					2.4
	Variety				8.1					13.2					2.5
$LSD_{0.05}$	Variety				7.94					-					0.43

Table 3. Total biomass, Harvest index and Leaf area index in the water x variety experiment in 2010 dry season

Variety	Biomass Yield (g m^{-1})					Harvest Index (HI)					Leaf Area Index (LAI)				
	AWD$_1$	AWD$_2$	AWD$_3$	AWD$_4$	Mean	AWD$_1$	AWD$_2$	AWD$_3$	AWD$_4$	Mean	AWD$_1$	AWD$_2$	AWD$_3$	AWD$_4$	Mean
IR 77080 -B-34-3	520.3	503.9	500.3	456.2	**495.2a**	0.32	0.32	0.28	0.32	**0.31**	0.99	0.90	1.00	1.28	**1.04**
WAB 880 -SG-6	532.8	584.2	548.7	501.3	**541.8a**	0.33	0.25	0.30	0.31	**0.30**	0.99	1.55	1.46	0.93	**1.23**
UPL Ri 7	312.0	301.1	354.3	309.0	**319.1c**	0.41	0.40	0.31	0.30	**0.35**	1.20	1.35	1.29	1.24	**1.27**
Aerobic 1	398.8	432.1	453.3	421.9	**426.5b**	0.32	0.33	0.28	0.29	**0.31**	1.15	1.22	1.43	1.28	**1.25**
Mean	**440.9**	**455.3**	**464.2**	**422.1**	-	**0.34**	**0.33**	**0.29**	**0.31**	-	**1.08**	**1.23**	**1.29**	**1.18**	-
F-test	Water Regime				ns					ns					ns
	Variety				1%					ns					ns
	Water Regime * Variety				ns					ns					ns
CV %	Water Regime				13.4					25.5					34.5
	Variety				18.0					20.3					33.9
LSD$_{0.05}$	Variety				57.4					-					-

Table 4. Crop growth rate (CGR) at PI, Flowering and Maturity stage in the water x variety experiment in 2010 dry season

Variety	CGR (PI to Flower)					CGR (Flower to Maturity)				
	AWD_1	AWD_2	AWD_3	CF	Mean	AWD_1	AWD_2	AWD_3	CF	Mean
IR 77080 -B-34-3	8.33	7.82	6.89	7.84	**7.72a**	6.02	6.15	6.70	4.93	**5.95**
WAB 880 -SG-6	7.32	9.38	7.73	6.88	**7.83a**	7.49	6.68	7.57	7.08	**7.20**
UPL Ri 7	3.89	3.21	2.71	3.79	**3.40c**	3.80	4.23	5.96	3.63	**4.41**
Aerobic 1	4.57	4.88	4.14	4.59	**4.55b**	4.96	5.67	6.97	5.92	**5.88**
Mean	**6.03**	**6.32**	**5.37**	**5.77**	-	**5.57**	**5.68**	**6.80**	**5.39**	-
F-test	Water Regime				ns					ns
	Variety				1%					ns
	Water Regime * Variety				ns					ns
CV %	Water Regime				31.8					35.5
	Variety				23.4					52.0
$LSD_{0.05}$	Variety				0.98					-

At maturity, there was no significant difference in biomass yield among water regimes tested, IR 77080-B-34-3 and WAB 880–SG-6, however, had significant higher biomass than the other varieties (Table 3). The relative biomass can be attributed by genetic differences and the rate of its growth. No interaction effect of variety and moisture regimes was observed on biomass. In general, harvest index was not significantly different by both variety and water regime. Harvest index range from 0.29 to 0.35 under different water levels and 0.30 to 0.35 among varieties, respectively.

There was no significant difference in leaf area index under different moisture level, and LAI among varieties were not significantly diffferent, as well. Interaction between moisture level and variety failed to show significant influence. Result showed that means of the crop growth rate were significantly different between PI and Flowering stage but not Flowering to Maturity stage (Table 4). Crop growth rates of WAB 880-SG-6 and IR 77080-B-34-3 were significantly higher than those of the others at PI to flowering stage.

Table (5) showed the interaction effect of variety and moisture regime failed to reach significant level on water use efficiency. All pairs of variety means were significantly different in water use efficiency with the following trend: Aerobic 1 > UPLRi 7 > WAB 880-SG-6 > IR 77080-B-34-3. Water use efficiency responsed by variety ranged from 0.49 to 0.65 kg m^{-3} (Table 5 and Figure 3). As responsed by water regime, water use efficiency under continuous flooding was significantly lower than those of AWD_1 and AWD_2 but not significantly different from AWD_3. Value ranged from 0.30 kg m^{-3} in CF to 0.70 kg m^{-3} in AWD_2 (Figure 4). Higher water use efficiency in AWD_1 and AWD_2 were attributed to less water use than CF even though their yields were more or less the same.

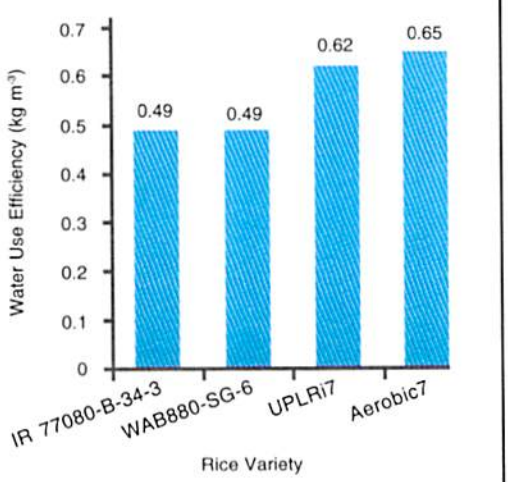


Figure 3. Water use efficiency as responsed by Variety

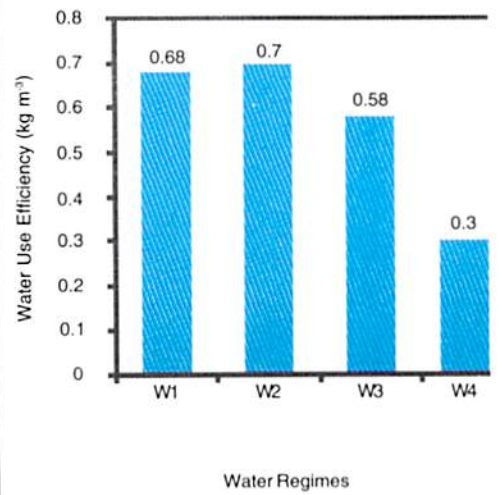


Figure 4. Water use efficiency as responsed by water regimes

Table 5. Total Water Use and Water Productivity as responsed by variety and water level in the experiment

Variety	CGR (PI to Flower)					CGR (Flower to Maturity)				
	AWD_1	AWD_2	AWD_3	CF	Mean	AWD_1	AWD_2	AWD_3	CF	Mean
IR 77080 -B-34-3	699	675	854	1562	**947a**	0.50	0.58	0.62	0.27	**0.49b**
WAB 880 -SG-6	621	659	803	1523	**902b**	0.65	0.54	0.52	0.28	**0.49b**
UPL Ri 7	413	404	490	1092	**600d**	0.83	0.78	0.55	0.34	**0.62a**
Aerobic 1	469	443	565	1161	**660c**	0.75	0.89	0.65	0.31	**0.65a**
Mean	**551b**	**545b**	**678b**	**1335a**	-	**0.68a**	**0.70a**	**0.58ab**	**0.30b**	-
F-test	Water Regime				1%					1%
	Variety				1%					1%
	Water Regime * Variety				1%					ns
CV %	Water Regime				29.8					64.6
	Variety				2.5					25.6
$LSD_{0.05}$	Water Regime				185.3					0.29
	Variety				13.7					0.10
	Water Regime * Variety				27.5					-

Conclusion

Aerobic rice, through it can yield 3-6 t ha^{-1} in the tropic (George *et al.*, 2002), can suffer from immediate yield failure. In this field experiment, the yields of tested aerobic rice varieties varied 3.08 t ha^{-1} to 4.03 t ha^{-1}, and the total water use ranged some from 490 mm to 1350 mm. Irrigated at 5 cm water depth when the water level reached 30 cm below soil surface (AWD_3) which consumed 625 mm of irrigation water and produced 3.74 t ha^{-1} paddy that was similar yield to continuous flooding that consumed irrigation water (1350 mm) two folds much higher than AWD_3.

Compared with CF, different threshold levels of AWD conditions did not affect on yield, yield components and growth attributes. However, AWD consumed significantly less water than CF and can save irrigation water by 49% to 59% of that used in CF. However, total water use was not significantly different among different threshold levels of AWD conditions. Under AWD_1 in which irrigated when the water level reached 15 cm below soil surface, more frequent irrigation was needed with shorter interval, and under AWD3 in which irrigated when the water level reached 30 cm below soil surface, less frequent irrigation was required with wider interval.

Under water scarce irrigated areas, water shortage may create an extended periods of aerobic soil conditions during the rice growing season, any one of AWD conditions can be appropriate as a water saving technology depends on the time of irrigation water availability.

The higher yield of IR 77080-B-34-3 and WAB 880-SG-6 over the other varieties can be attributed to their heavier grain weight and higher biomass weight. Crop growth rate of IR 77080-B-34-3 and WAB 880-SG-6 were significantly higher than those of UPLRi 7 and Aerobic 1 varieties but harvest index (ranged from 0.30 to 0.35) and leaf area index (ranged from 1.04 to 1.27) were not significantly different among varieties. However, further study will be needed to clarify the interaction of plant growth development and moisture level in AWD condition.

Acknowledgement

Grateful thanks to Dr. Ruben Lampayan, leader of water saving technology group in IRRI, Philippines, for his technical support and it is also part of the Irrigated Rice Research Consortium (IRRC) project. Special acknowledgment and sincere gratitude to U Khin Soe, Director General, Department of Agricultural Research, for his encouragement and permission to implement this research work.

References

Bouman, B.A.M., S. Peng., A.R. Castaneda and R.M. Visperas. 2005. Yield and water use of irrigated tropical aerobic rice systems. Crop, Soil and Water Science Division, International Rice Research Institute (IRRI).

George, T., R. Magbanua., D.P. Garrity., B.S. Tubana and J. Quiton. 2002. Rapid yield loss of rice cropped successively in aerobic soil. Agrom. J. 94, 981-989.

Parao, F. 1985. Yield components: Rice Production Training Series, IRRI, Los Bonos, Laguna, Philippines.

Selvaraju, R. and M.R. Iruthayarai. 1993. Effect of irrigation scheduling, methods of irrigation and nitrogen level on growth analysis parameters of maize. Madras Agriculture Journal. 80: 562-565.

Taha, M and J. M. L. Gulati. 2001. Influence of irrigation on yield and moisture utilization of groundnut (*Arachis hypogaea* L.) Indian Journal of Agronomy. 46 (3): 523-527.

Tuong, T. P and B. A. M. Bouman. 2002. Rice production in water scarce environment. In Water vs. Rice Production. Proceeding of Water Productivity Workshop. p.146.

Yoshida, S. 1981. Fundamentals of Rice Crop Science. International Rice Research Institute, Los Bonos, Laguna, Philippines. pp. 3-29.

SUSTAINABLE AGRICULTURE DEVELOPMENT IN BANGLADESH: CRITICAL ECOLOGICAL ISSUES AND CHOICE OF TECHNOLOGY

Muhammad Salim[1] and A. K. M. Mominul Islam[2]

Abstract

Recently the land productivity in Bangladesh is declining fast due to HYV (High Yielding Variety) rice production, intensive cropping, and indiscriminate use of fertilizers, pesticides and water irrigation. Such an extensive dependence on agrochemicals leads to various negative effects on environment and causes natural-health hazards. Ecotechnology and sustainable development concept would be very much helpful to overcome the solution. It is time to build a new paradigm of policies that can promote sustainable agriculture to help ensure food security, anchor rural development, provide resources for the livelihood and adequate incomes of a majority of people, all without destroying the environmental base.

Key Words : Green revolution, crop intensification, HYV, sustainability, local vorities

Introduction

Bangladesh is an agriculture-based country and most Bangladeshis earn their living from agriculture. Soil fertility and agro ecological condition is favorable for growing a large number of crops. Agriculture is the single largest producing sector of the economy since it comprises about 22% of the country's GDP and employs around 48.1% of the total labour force (BBS, 2009). The performance of this sector has an overwhelming impact on major macroeconomic objectives like employment generation, poverty alleviation, human resources development and food security.

Although rice and jute are the primary crops, wheat is assuming greater importance. Tea is grown in the northeast. Because Bangladesh's fertile soil and normally ample water supply, rice can be grown and harvested three times a year in many areas (Figure 1).

Food grains are cultivated primarily for subsistence. Only a small percentage of total production makes its way into commercial channels. Other Bangladeshi food crops, however, are grown chiefly for domestic market. They include potatoes and sweet potatoes, with a combined record production of 1.9 million tons; oil seeds, with an annual production of 0.3 million tons and fruits such as bananas, jackfruit, mangoes and pineapples. Estimates of sugarcane production put annual production more than 7 million tons per year.

Bangladesh has a vast population of 160 million which accounts 1084 per square kilometre (BBS, 2009). Population pressure continues to place severe burden on productive capacity, creating a food deficit, especially for cereal production. Foreign assistance and commercial imports fill the gap (Figure 2-4).

1. Professor, Department of Agronomy, Bangladesh Agricultural University
2. Assistant Professor, Department of Agronomy, Bangladesh Agricultural University
Email address of the lead author: msalimafa@yahoo.com

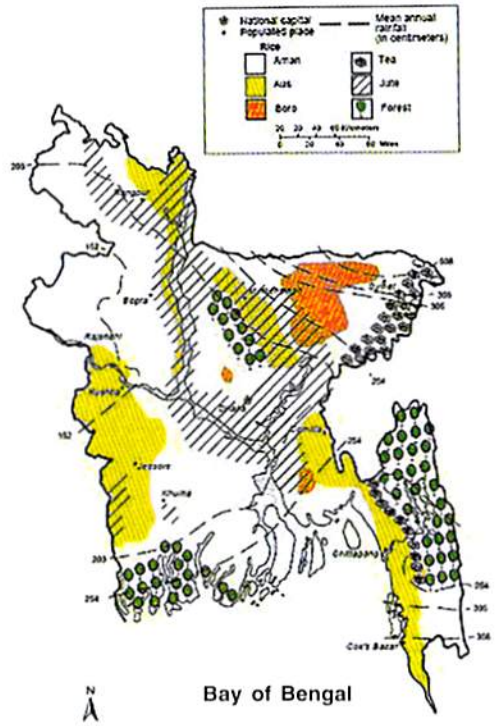


Figure 1. Map of Bangladesh showing the growing areas of major agricultural products

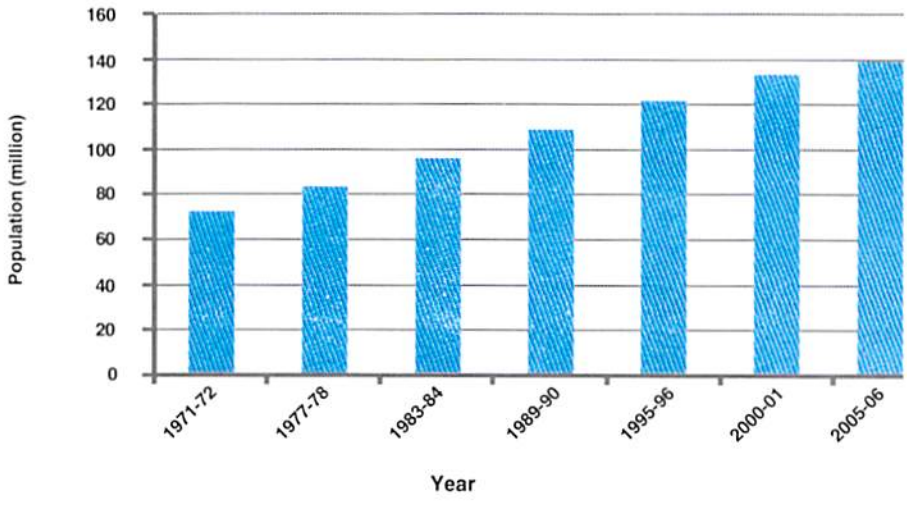


Figure 2. Trend of population increase from 1971 to 2006

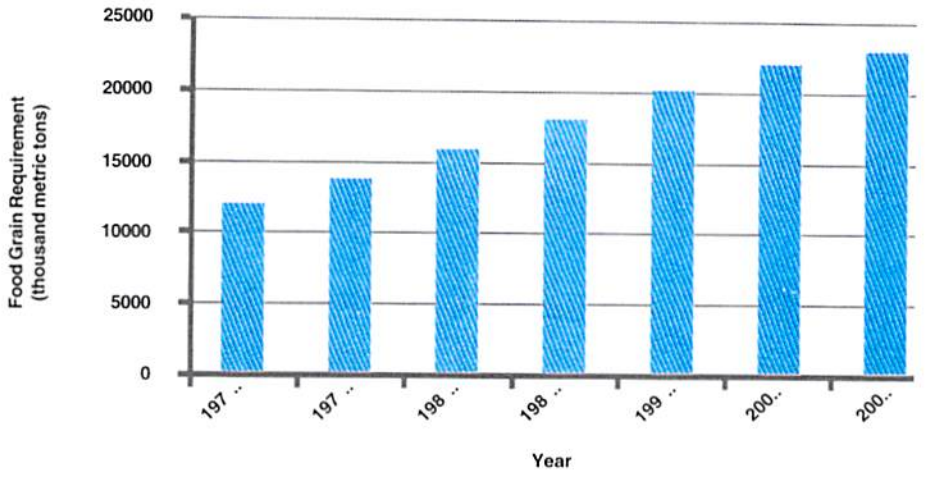


Figure 3. Food grain requirement from 1971 to 2006

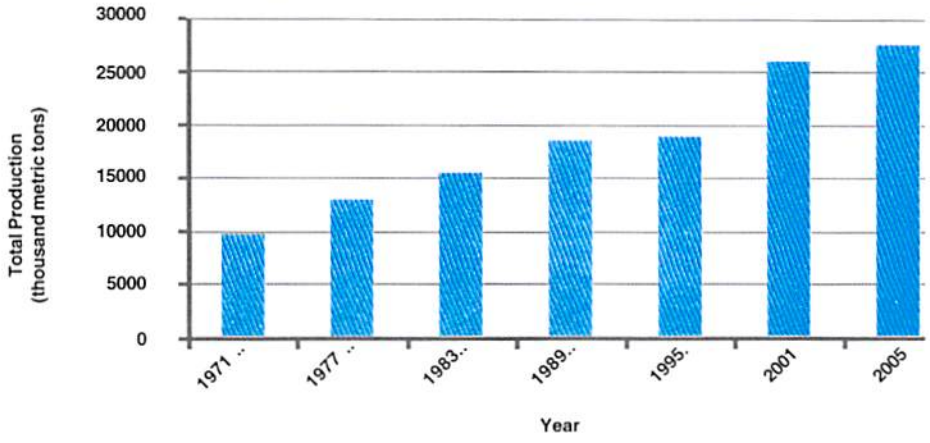


Figure 4. Total production of cereals (rice, wheat and maize) from 1971 to 2006

Bangladesh is one of the most land scarce countries in the world. Its per capita net cultivable land is least (0.06 ha) in the world except a few city states like Vatican, Singapore etc. Bangladesh already have a huge population, which is beyond its carrying capacity. Because of weak economic back-bone the country cannot depend on import of stable flood. Therefore, it is struggling to achieve self-sufficiency in food. Analysis of land use pattern during last half century indicates that agricultural land is reducing constantly mainly due to development of infrastructure for the increasing population (Table 1 and Figure 5). On the other hand, net cropped area increased until early 1990s because of crop intensification; which also showing sign of decrease due to reduction of net cultivated area. The two opposing trends, reduction of agricultural lands and increase of population, offer immense challenge to future food availability (Islam, 2000). In order to feed the huge population green revolution has emerged in 1960s and priority was given to produce more food in terms of grain through intensification of land usage. It has created a tremendous pressure

on limited land resources. New crop variety (HYV) was introduced as well as chemical fertilizer and pesticides, irrigation in the name of modernization (Robbani *et al.*, 2007). As a result production has increased by manifold. For a shorter period Bangladesh has achieved so called self sufficiency in food (rice). A suicidal policy of just extraction of soil was followed. A lot of HYVs, Hybrids has introduced that require increased amount of chemicals. Soil fertility conservation issue has been totally ignored. As a result, soil is rapidly losing its fertility. Acreage production is getting downward despite of using high doses of chemical fertilizer and pesticides.

Table 1. Share of different land utilization components from 1951 to 2008 (BBS, 2009)

Period	Area coverage (%)				
	Forest	Culturable waste land	Current fellow land	Net cropped area	Non-arable land
1951-55	9.12	11.59	4.25	60.90	14.12
1956-60	15.96	5.69	3.86	58.16	16.34
1961-65	15.53	5.17	2.65	59.68	16.98
1966-70	15.48	2.82	2.43	61.14	18.13
1971-75	15.58	1.98	4.80	59.02	18.62
1976-80	15.39	1.83	5.10	58.82	18.86
1981-85	14.72	1.88	4.48	59.62	19.31
1986-90	13.21	2.16	5.91	57.76	20.96
1991-95	12.86	4.14	3.35	53.21	26.43
1996-00	15.42	3.13	2.62	53.57	25.26
2001-05	17.52	2.05	2.76	54.10	23.57
2006-08	17.51	1.70	4.21	52.49	24.09

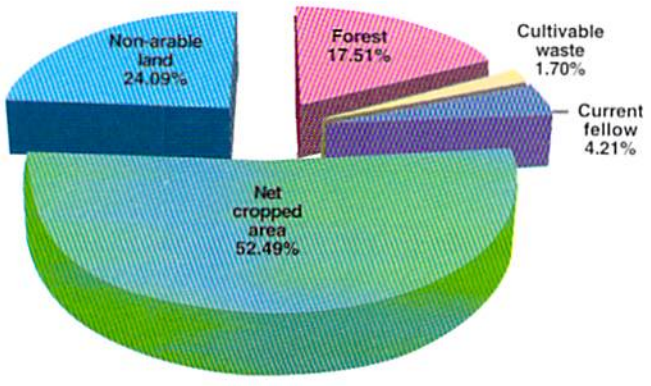


Figure 5. Pie graph shows the land utilization statistics of Bangladesh in 2006-08

In the past, most agricultural aid has promoted the Green Revolution model, which uses seeds that respond well to large doses of inorganic fertiliser and chemical pesticides. These few seed varieties have displaced a wide range of traditional seeds, thus eroding crop biodiversity. There is also mounting evidence of, and growing concern with, other ecological problems, such as decreasing soil infertility, chemical pollution of land and water resources, pesticide poisoning, and pest infestation due to growing pest resistance to pesticides. These are not *ad hoc* problems, but symptoms of a technological system in decline. The ecological and health hazards should no longer be considered as the necessary costs to an economically and technically superior system, because the system's most important claimed benefit, high productivity, is itself now in question. In areas where the model has operated for a longer period, there is evidence of declining yields and rising costs. In 1993, the FAO chief for Asia Pacific declared the Green Revolution era over. There is increasing deficiency of trace elements in the soil because of intensive use mineral fertilisers, while continued high dependence on pesticides is not technologically sustainable. He revealed a yield decline of 1 to 8% per year in some fields using the Green Revolution technique, a situation described as "a recipe for disaster within one generation". Developments in some of the best managed experimental farms have added to the pessimism. In International Rice Research Institute (IRRI) test plots, varieties that yielded 10 tonnes per hectare in 1966 were yielding less each year and produced less than 7 tonnes per hectare by the mid-1990s. IRRI scientists attributed the declines to environmental degradation, with irrigated land unable to cope. The detrimental changes included a reduction in the period when the soil was dry, the substitution of inorganic for organic fertilisers and a greater uniformity in the varieties grown.

With disillusionment setting in on the Green Revolution, there is a danger that agriculture aid will turn to genetic engineering. Companies, universities and foundations have already pumped enormous funds into biotech research. But the claimed benefits of genetic engineering are far from proven, while there is increasing evidence of real and potential risks. Scientists now point to scientific laws of the genetic engineering paradigm, showing why it is impossible to predict the consequence of transferring a gene from one organism to another in a significant number of cases. This calls into question the value or usefulness of genetically engineered (GE) crops.There is a growing evidence of the hazards to human health of consuming foods containing GMOs. Consumers around the world are now voting against GE foods and opting for organic food.

Consequences of Green Revolution: After the green revolution, when technology and the notion of chemical agriculture were introduced, it seems that the gross production of main grain, rice has increased. It has, however, created a large negative impact on rural farmers and environment. Chemical agriculture is only oriented to economic profit, ecological and social factors are totally ignored. Chemical agriculture is totally anti-natural and destructive. Consequently this agricultural technology creates many problems. Prominent among these are topsoil depletion and degradation, ground water contamination, the decline of family farms, continued neglect of the living and working conditions for farm labourers, increasing costs of production, and the disintegration of economic and social conditions in rural communities, health hazards due to food degradation and environment (soil, air and water) pollution because of agricultural poisons. Whole issues may be studied under two broad headings such as ecological problem and economic problem.

Ecological problem:

Degradation of soil:

Use of inorganic fertilizer and pesticides without use of any organic fertilizer results lack of organic matter supply which cause a lot of problems to the soil. Soil become hard, water holding capacity get reduced, soil pH become imbalance that cause some micronutrient deficiency, reduced soil microbial activities that results less availability of plant nutrients.
After 4 decades of modern agricultural practices, Organic Matter (OM) status of Bangladesh soil has become one of the lowest of the world. At present the average OM content of Bangladesh soils is less than 1%, ranging between 0.05-0.9% in most cases. Organic matter supply in soil is one of the major constraints to the agriculture of the country.

Increasing pest problem:

Degraded soil become unhealthy and unhealthy soil grows unhealthy plants. Without considering the root cause use of chemical poisons to destroy the pest and consequently the pest problem is not solved and become worsen.

Food quality degradation:

The product grown with excessive chemical fertilizers and pesticides are low in quality. This low food quality becomes apparent in taste and preserving capacity. Chemically grown product has less nutrient content (protein, vitamins and minerals) and higher water content. The high water content may be one of the main reasons for lack of taste and low preserving capacity of chemically grown products.

Pollution of soil, water and air:

Use of chemical pesticides results pollution of the environment as they are chemical poison. They are very much effective in killing living things and have long term residual effect. The poison pollute the product first and then soil, air water consequently. This pollution results in poisoned product, soil degradation, and the disappearance of fish, birds and other animals.

Moreover, due to using excessive pumping ground water for irrigating crops, the problem of arsenic pollution of ground water is now well recognized in Bangladesh (Brammer and Ravencroft, 2009). It has recently become apparent that arsenic polluted water used for irrigation is adding sufficient arsenic to soils and rice to pose serious threats to sustainable agricultural production in the country and to the health and livelihood of affected people.

Health hazards:

People experienced health hazards in two ways. Firstly, people eat the poisoned agricultural products and other contaminated food like, meat, milk, fish etc. from chemical agricultural production. The poison accumulates in the living body and through the food chain, the poison is condensed and create different health hazards. The ultimate destination of any chemical poison, wherever it is used, is the human body (Figure 6). Secondly, the chemical pesticides directly affect the farmers who use it. In Bangladesh, most farmers handle pesticides without protection for their bodies and they are usually the most serious victims.

Disappearance of local genetic resources:

Local varieties are the genetic base for improving seeds and are very important resource for the future. However, local varieties are disappearing each year. The main reason is the introduction of HYV seeds and Hybrid seeds. That also accelerates mono-culture and create ecological imbalance in agriculture. Once there were 10,000 different kinds of rice varieties available in Bangladesh. After green revolution era many of them have extinct. But many of those varieties were resistant to drought, insect pests and diseases with excellent cooking qualities.

Economic problem:

Increase in production cost:

Chemical agriculture is mainly dependent on external inputs and production cost increase is unavoidable. In the beginning of green revolution farmers used to use only urea about 50 kg per acre. However, at present farmers are using 6 types of different fertilizers such as urea, TSP, MP, Gypsum, Zinc and Boron and some where Molybdenum. The amount is also manifold higher than the beginning stage. Also the price of the chemical fertilizers has increased rigorously.

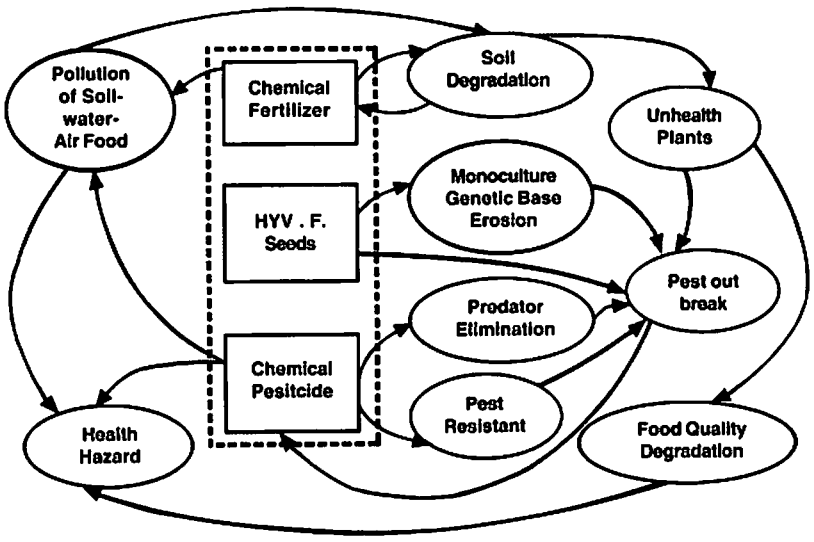


Figure 6. Green Revolution in Bangladesh and its consequences impact of sustainable agriculture practices

Decreased in yield:

Though farmers increase the quality of external inputs, they can not get as much production as before. The reason for the decrease in yield is soil degradation. It is obvious that degraded soil never produce good yields.

Sustainability, ecology and technology:

The word sustainability is now-a-days linked to almost all activities related to development that may involve agriculture, education, industry, health and sanitation etc. Sustainable crop production is one that is agronomically productive and economically viable and relatively stable over years under adverse ecology. Sustainability in agriculture is an ability of an agricultural system to maintain its productivity when subjected to abiotic and biotic stresses (Mondal, 2005).

Sustainable production practices involve a variety of approaches. Specific strategies must take into account topography, soil characteristics, climate, pests, local availability of inputs and individual grower's goal. Despite the site-specific and individual nature of sustainable agriculture, several general principles can be applied to help growers for selecting appropriate management practices:
Selection of species and varieties those are well suited to the site and to the given condition:
Rational management of crops and cultural practices to enhance the biological and economical stability,
Management of the soil to enhance and protect soil quality
Consideration of farmers' goals and life style choices

In doing so, we cite here an example of an approach is may be called an ecotechnology which shows the detail delineation of cultivable lands, roads, water bodies and direction of water flow during wet season. Such location specific information is helpful to understand site-specific and individual nature of sustainable agriculture.

Uchida *et al.* (1995) proposed a "rural hydrology" approach for investigating and planning of rural infrastructure build-up in the floodplain zone of Bangladesh (Figure 7). The rural hydrology approach, a form of "alternative engineering," requires the following minimal set of items such as a motorcycle or bicycle, feet to work around, an eye to see the real environmental conditions, an ear to listen to those who are informed of the local conditions, a flexible mind to share with local people, in order to identify land and water conditions, constraints to development and the real needs of the locality and local people.

Here, a case study is documented. The dynamic hydrological environment of the flood plain of Tangail, Bangladesh was analyzed at the level of the Union and the results were applied to formulate plans for building rural infrastructures including Union and village roads, bridges and culverts, low cost river-bank protection walls etc. Such as local specific planning is a real example of sustainability.

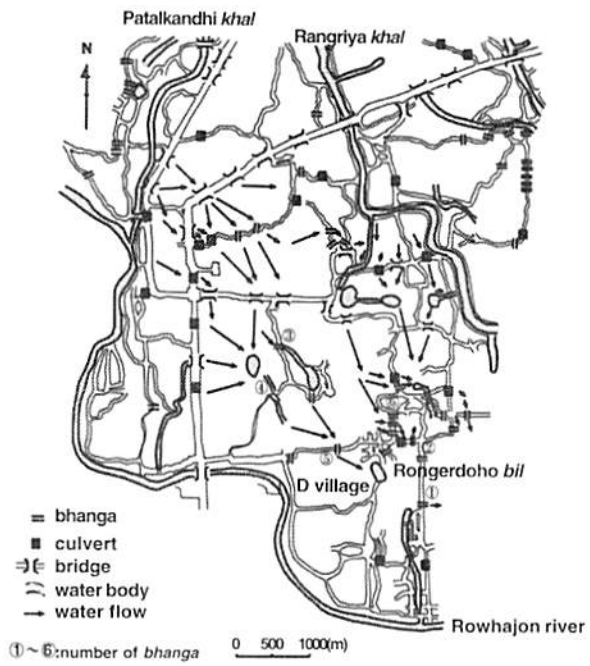


Figure 7. Rural hydrology - A model

In another example (Figure 8-10), Salim *et al.* (1989) show the local land classification which is directly related to select crops and cropping in a low-lying area, Jawar, Bangladesh. Here using the local land classification system, the entire village areas were classified into more detailed land units in order to analyze the relationship between toposequences and distribution of cropping patterns. Understanding the toposequences and change of water–level and schematic cross-section that shows the distribution of major cropping pattern of that area which can be said to be a result of the farmers' adaption with both traditional and modern technology, to the given natural environment of the low-lying areas of Bangladesh.

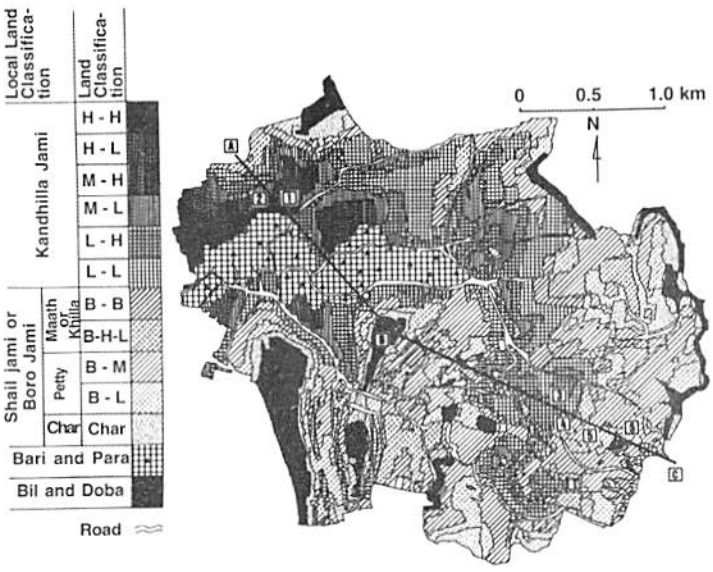


Figure 8. Local land classification of Jawar

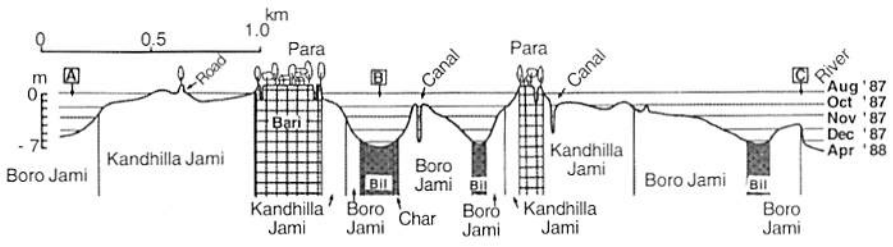


Figure 9. Water regimes of Jawar

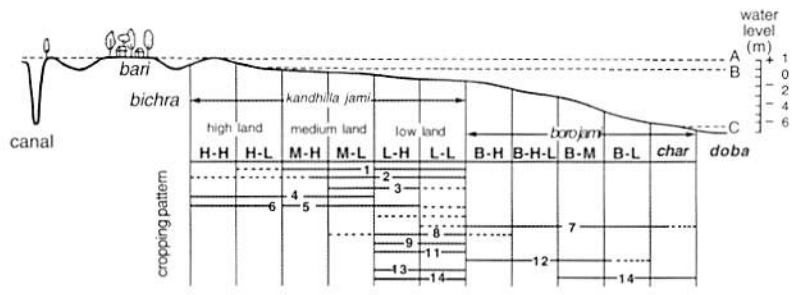


Figure 10. Distribution of major cropping pattern in relation to topography at Jawar

We must choose such environment friendly technology that can meet the present need and also conserve the resources for future use. We have huge natural resources, thousands of indigenous knowledge gathered by our ancestors which they learnt from nature. We require necessary harmonization between those indigenous knowledge and new technologies to make a sustainable agriculture practice.

Conclusion

Bangladesh is under tremendous pressure to produce food grain for an image population utilizing very limited land resources of 8.3 million hectare. It is claimed by the government that if the natural factors remain favourable Bangladesh can grow sufficient cereals for its nation. Now the question is how long? It has already proved that land and other natural resources cannot be exploited endlessly by this time we have damaged our soil, genetic and other natural resources to a great extent. We must find the alternate wayout before going the situation at an unprecedented level. Sustainable agriculture concept as stated above would be very much helpful to overcome the solution.

References

BBS. 2009. Statistical year book of Bangladesh 2009. Bangladesh Bureau of Statistics. Statistics Division, Ministry of Planning, Govt. of the People's Republic of Bangladesh, p.127.

Brammer, H. and Ravencroft, P. 2009. Arsenic in groundwater: a threat to sustainable agriculture in south and south-east Asia. Environ. Int'l, 35 (3): 647-54.

Islam, Z. 2000. Land use pattern of Bangladesh and future food production challenges: are we heading towards a disaster? Bangladesh Environment 2000. An outcome of ICBEN-2000. (M. Feroze Ahmed Edt.) pp. 596-606.

Mondal, M. H. 2005. Challenges and opportunities of sustainable crop production in Bangladesh. Key-note paper presented at the 8th biennial Agronomy convention of Bangladesh Society of Agronomy held at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, on 26 May 2005.

Robbani, M.; Siddiquee, S. U.; Zaman, S. and Nakamura, H. 2007. Agriculture in Bangladesh: Recent trend and agro-environment toward sustainability. Shinshu Daigaku Nogakubu Kiyo. pp. 17-25.

Salim, M.; K. Ando; H. Uchida and K. Tanaka. 1990. Village-level studies on rice-based cropping systems in the low-lying areas of Bangladesh. I. Cropping patterns and their distribution in *Haor* and *Bil* areas. Japn. J. Crop Sci., 59 (3): 518-527.

Uchida, H.; K. Ando; M. Salim and S. M. A. Hossain. 1995. Rural hydrology: an approach to rural infrastructure build-up in Bangladesh Rural Development. Southeast Asian Studies, 33 (1): 66-81.

SUSTAINABLE ON FISHWAY DESIGN AT CENTER LAO PDR

Oudom Phonekhampheng[1], Garry Thorncraf[1], Lee Baumgartner[1] and Douangkham Singhanouvong[1]

Abstract

Fish passage through an experimental vertical-slot fishway facility was assessed at a floodplain regulator on the Mekong River in Central Laos between April and July 2009. Experiments sought to determine the influence of floor slope (1:15 or 1:8) on passage success with a view to developing a series of optimal design criteria for the construction of vertical-slot fishways at other barriers to fish passage in the Lower Mekong Basin. A total of 14,661 fish from 73 species were captured during the experiments. Catches were dominated by riverine (white) (n = 51; 69% of total) and floodplain (black) species (n = 15; 20%) which represented 19 families in total. The work demonstrated that fish were actively attempting to gain upstream passage and displayed strong migratory behaviour during river level rises. Migratory activity was greatest during sharp rises in water level, but reduced substantially when river level fell. Fish community composition varied greatly among different floor slope and control groups. More species were collected from control samples but the greatest number of fish was collected when the fishway was configured on moderate slopes (1:15). A range of size classes were also collected from control samples and moderate slope treatments samples but when established on a steeper gradient, catches were dominated by larger fish. The study successfully demonstrated that vertical slot fishways can provide passage for species attempting to move laterally onto Mekong River floodplains. The construction of these structures may therefore represent a suitable management tool to help reinstate migration pathways at small-scale migration barriers.

Key Words : Flood plain, fishway, Mekong basin, fish migration

Introduction

Floodplain ecosystems are important ecological assets accounting for much of the natural production in large river systems (Bayley, 1995). Virtually all floodplain systems require regular flooding to maintain connectivity with main river channels and regular inundation of releases nutrients and restores lateral connectivity (Junk *et al.*, 1989). Floodplain soils are extremely fertile and high nutrient loads favour agricultural development (Bayley, 1995). Regular flooding however, decreases the agricultural productivity of the floodplain because it is difficult to permanently crop areas that are frequently inundated (Islam and Braden, 2006; Sparks, 1995). This paradox has necessitated the development of engineering solutions such as levee banks, regulators and sluice gates to reduce inundation events. These engineering structures either reduce or eliminate natural floodplain functions and productivity quickly decreases, particularly in areas of intensive development (De Graaf, 2003; Thoms, 2003). Reductions in productivity and accessibility subsequently facilitates the decline of floodplain fauna which has been observed in many rivers throughout the world (Kingsford, 2000).

1. Faculthicuy of Agriculture University of Loas PDR

The Mekong is one of the world's major catchment systems. It drains a total area of 795,000km^2, is over 4,000km in length and supports over 60 million people. Fisheries are immensely important throughout the lower Mekong basin providing on average 48% (Lao PDR) and 79% (Cambodia) of the animal protein intake (Pagdee *et al.*, 2007). More than 80% of rural households in the Mekong basin in Thailand, Lao and Cambodia are involved in a capture fishery which has a first-sale value of between US$2,000–4,000 million per year (Hortle, 2007). The annual yield from the capture fishery in the lower Mekong Basin is about two million tonnes, which is approximately 2% of the total world marine and freshwater catch. Whilst the development of floodplain ecosystems has had a worldwide impact of fisheries production, impacts on the Mekong River are becoming increasingly apparent (Hortle *et al.*, 2008)

The Mekong River has an extensive floodplain system extending from the lowland reaches of Laos and terminating in large and complex wetland systems in Thailand, Vietnam and especially Cambodia (Kummu *et al.*, 2005). The Mekong River floodplains are among the most productive in the world, but a lack of ecological understanding precludes effective management of the system (Campbell, 2005). Fish of the Mekong floodplains are adapted to high natural mortality through early sexual maturation and high fecundity (Lowe-McConnell, 1987). These adaptations provide resilience to fishing exploitation provided floods of adequate duration and magnitude frequently inundate floodplain habitat and help to maintain productivity (Bayley, 1995). Construction of dams in the upper Mekong however, are beginning to reduce incidences of flooding in downstream reaches, and inundation events are declining in frequency (Lu and Siew, 2006). Further development of floodplain systems, with agricultural infrastructure, are also reducing lateral connectivity in many areas (Nguyen and De Silva, 2006; Jorgensen and Poulsen, 2000). Continued development of these important ecosystems requires the development of effective mitigation techniques which can restore lateral connectivity with the main river channel.

In large rivers, most rehabilitation efforts for fish are focused on developing fishways for main channel barriers to longitudinal connectivity (Clay, 1995; Odeh, 1999; Stuart *et al.*, 2007). Fishways can be unsuccessful in large biodiverse rivers particularly at high barriers (> 12m) where large-scale habitat changes, reductions in flow regimes and water quality issues often have a much greater impact than reduced connectivity (Fernando Mayer and Angelo Antonio, 2008). Many fishways, however, have been successfully developed to pass a wide range of species and size classes at smaller structures (< 6m) (Andersen *et al.*, 2007; Barrett and Mallen-Cooper, 2006; Baumgartner and Harris, 2007; Bunt, 2001; Hamano *et al.*, 1995; Mallen-Cooper and Brand, 2007). In many instances these can provide passage for high numbers and biomasses of fish over relatively short time periods (King and Torre, 2007; Kowarsky and Ross, 1981; Mallen-Cooper, 1996; Roscoe and Hinch, 2009; Schmetterling *et al.*, 2002; Schwalme and Mackay, 1985; Stuart *et al.*, 2008a; Stuart and Mallen-Cooper, 1999; Stuart *et al.*, 2008b). Importantly, engineering specifications for these fishways are well-known and can be applied to any small barrier provided local hydrology, species composition and ecological objectives are clearly defined and understood.

Several fishways have been constructed in the Lower Mekong Basin, but none demonstrate evidence of attempting to incorporate knowledge of local species and hydrology into fishway design (Sripatrptasite, 2005). The present study sought to determine whether a vertical slot fishway can be designed to provide passage for Lower Mekong fish species attempting to access floodplain habitat. Experimental manipulations of flow and turbulence were used, under field conditions, to determine the optimal design criteria to guide potential application at other sites in the Lower Mekong Basin. Cues to migration and the influence of changing water levels were also investigated.

Materials and Methods

The study was conducted at a floodplain regulator adjacent to the Mekong River at Pak Peung village (Bolikhamxay province) in central Laos. The concrete regulator was constructed to prevent inundation of floodplain rice crops during increases in Mekong River level during the wet season. The regulator is 10m high and contains three manually-operated sluice gates which release water from an upstream wetland. Each gate is capable of delivering a maximum 80 ML.day^{-1} (0.93 m.s^{-1}). Gates are initially operated to drain the associated wetland to prevent crop damage following high rain evens (early in the wet season). The gates are adjusted daily and during this period fish could move downstream through the sluice gates, but upstream passage is not possible. The gates are closed during high Mekong levels to prevent further crop damage from water entering the wetland (usually later in the wet season). Under these conditions, the regulator is a barrier to both upstream and downstream movements.

Experimental fishway unit

An experimental fishway unit was constructed to determine whether technical fishways are capable of providing passage for local migratory species at the Pak Peung site. A vertical slot fishway, constructed out of reinforced mild steel (3mm width) was installed parallel with the right hand training wall downstream of the regulator and secured in place with a combination of sandbags and high-tensile cable. A block and tackle with an endless chain was fitted to an overhead gantry and used to manipulate the slope of the fishway. A sandbag wall was erected upstream of the structure to direct flow from the regulator through the experimental unit. The fishway unit comprised four cells which were 1500 mm x 1000 mm. Vertical slots were 1.4 metres high with a nominal slot width of 150 mm.

Experimental design

Fish were collected from two locations within the fishway over a period of 44 days between April and July 2009 and sought to compare fish communities attempting to ascend the fishway (control) with fish successfully ascending (treatments). Treatments involved establishing the fishway on different floor slopes, moderate (1:15 or 6%) or steep (1:8 or 12%), and quantifying the number of fish successfully ascending. Experimental treatments began by carefully adjusting the fishway until the required slope was attained. Once the desired hydraulic conditions were achieved, fish passage was assessed by placing a fish trap (1500 mm x 1000 mm x 400mm; 6 mm mesh) upstream of the last baffle.

The control sought to quantify the number of fish attempting to ascend the fishway and provided a basis for comparison with treatment replicates. Controls began by establishing the fishway on a moderate slope to provide an attraction flow for fish to approach the fishway. The trap was established downstream of the attraction jet and any fish attempting to enter the fishway were collected.

Each control and treatment replicate ran for 2 hours after which the trap was retrieved and any fish were identified, measured (total length), weighed and subsequently released. Replicates were completed each day between 700 and 1500. It was unknown whether the structure of migratory fish communities would vary with time of day. To control for this potential effect the fishway

was assessed using a randomised block design where one 'block' was completed every three days. Experimental treatments and the control were subsequently assigned to one of three potential time periods each day (Morning; 700 – 1000, Midday: 1100 – 1300, Afternoon: 1400 - 1700). The three replicates (control and two treatments) were completed per day but three days were required to complete all time of day and treatment combinations. A total of 6 full blocks were completed over the study period.

Data analysis

Data were analysed using S-PLUS and PRIMER V6.0. Differences in length distributions of fish collected from control and treatment samples were compared using a Kolmogorov-Smirnov (KS) pairwise comparison. This test computes a test statistic (ks) which is based on the largest difference between two cumulative length-frequency distributions. The length frequency data of all fish species were then pooled to construct length frequency histograms for each treatment and control.

Differences in fish community structure among experimental blocks, fishway slope and time of day were investigated using Permutational Analysis of Variance (PERMANOVA). All tests were based on square-root transformed data using Bray Curtis Similarities (with 999 permutations). 'Block' was treated as a fixed factor but both floor slope and time of day were random. It was largely unknown at the commencement of the study whether different species migrated at different times of the day. This was identified as a factor which could potentially confound experimental results if slope experiments were conducted in different diurnal periods. Preliminary analysis identified no differences in fish community structure could be attributed to time of day so it was removed as a factor from subsequent analysis to permit further exploration of the effect of floor slope and experimental blocks. Two-Way Analysis of Similarities (ANOSIM) was subsequently used to determine whether the fish communities among experimental groups (treatment and controls) or among daily experimental blocks. This test sought to identify both the effect of fishway slope and also any natural change in fish communities as time progressed through the experiment. In all ANOSIM tests, 999 Monte-Carlo randomisations were used to calculate approximate probabilities and Gobal R-values. Sample differences plotted using non-metric multi-dimensional scaling ordinations to visually represent any group differences.

Results

General catch information

Fish were extremely motivated to migrate. During regular collections fish were physically observed to jump from the water whilst attempting upstream migrations. This behaviour was observed both within the fishway, where fish actively jumped over baffles, and also on the apron of the adjacent weir. In total, 14,661 fish from 73 species were captured during the experiments (Table 1). Catches were dominated by riverine (white) species (n = 51; 69% of total) but several floodplain (black) species were also recorded (n = 15; 20%). Species represented 19 families in total, but 96% of the catch represented only five (Cyprinidae = 69%; Ambassidae = 22%, Belonidae = 4%; Clupeidae = 1%; Mastacembelidae = 1%) and 34 species comprised less than 10 individuals (Table 1). Three species *Parambassis siamensis* (n = 3,277), *Barbonymus gonionotus* (n = 3,206), *Rasbora dusonensis* (n = 2,625) comprised 62% of total catch. Eight species were unable to be indentified and are presently undergoing more detailed taxonomic classification.

Influence of fishway slope

Most individuals were collected during moderate slope treatments (n = 7,666) but the most species (n = 52) were collected from control samples (Table 1). Species appeared to fall within three main groupings based on passage success within the experimental unit. Firstly, there were species which only migrated when the fishway was established on a steep slope. These species (n = 20) were either absent, or collected in extremely low abundances during control and moderate slope treatments. Another group of fish which were collected only from control groups (n = 14) and were absent from treatments. The final group of fish (n = 39) were collected from both control and treatment groups irrespective of fishway slope.

A 3-factor analysis (based on the randomised block design) identified significant differences among blocks (PERMANOVA; Table 2) which arose from a progressive change in migratory fish community from the beginning to the end of the study period. Many fish were migrating at the commencement of experiments but numbers gradually decreased with time. Differences in fish community composition were also detected among different floor slopes (PERMANOVA; Table 2) because of changes in relative abundances of several species among experimental treatments. This was largely due to the high number of individuals were collected from the moderate slope group overall, and the absence of several species from control samples. For instance, *Parambassis siamensis*, *Rasbora rubrodorsalis* and *Xenentodon cancilla* were collected in significantly higher abundances from control samples than either treatment sample. In contrast, several species such as *Barbonymus gonionotus*, *Rasbora dusonensis* and *Osteochilus lini* were more frequently collected from the two treatment groups rather than the control. These differences in fish community composition provided separation of treatment groups in ordinal space (Figure 1). No significant differences among different diurnal periods indicated that the structure of the migratory community did not vary during daylight hours (PERMANOVA; Table 2).

Effect of flow on fishway use

Daily mean fish passage was relatively high early in the study but decreased substantially during the final stages (Figure 2). The commencement of the study period coincided with a sharp increase in water level within the Mekong River (from 2.39m to 4.40m) following substantial rainfall events in nearby catchments. Water levels eventually peaked and the total number of species and individuals collected substantially declined from both treatment and control samples. Attempting a correlation between river level and total fish migration numbers identified a poor relationship (R = 0.09) which occurred because most increases in fish migration occurred during the initial level rise suggesting that change in water level, may be a more meaningful factor (Figure 2) Migration rates were subsequently plotted against change in daily flow and a much stronger correlation was observed (R = 0.53; Figure 3). These observations provide preliminary evidence that migration rates and changing hydrograph could be inherently linked but the relationship was not consistent across species. *Xenentodon canciloides* continued to use the experimental fishway during a falling hydrograph whilst *Rasbora dusonensis*, *Barbonymus gonionotus*, *Osteochilus lini*, *Cyclocheilichtys armatus* and *Rasbora daniconius* were only collected during a rising hydrograph. These species were notably absent from collections whenever levels in the Mekong began to fall.

Size class differences

Fish were collected over a wider size range during the study (19 – 285 mm) but the greatest proportion of captured fish were relatively small (< 100 mm) (Figure 3). Fish collected from the control group were significantly smaller than fish collected from either of the two treatment groups (KS: $ks_{ctrl\ vs\ 100} = 0.240$, $p < 0.001$; $ks_{ctrl\ vs\ 200} = 0.415$, $p < 0.001$). *Clupeichtys aesiamnesis*, *Amblypharyngodon clulabhornae* and *Eosomis* spp were almost virtually absent from catches during steep slope experiments and no fish less than 40mm was able to ascend steep floor slopes. Changes in the catch of fish less than 100mm contributed to significant differences between both treatment groups (KS: $ks_{100\ vs\ 200} = 0.182$; $p < 0.001$). In contrast, catches of larger fish were higher on steeper slopes. Some species, including *Rasbora dusonensis*, *Barbonymus schwanenfeldii*, *Rasbora daniconius* and *Osteochilus lini* were poorly represented from control samples, but were more abundant when slope increased. Substantially more fish (80 – 120mm) were collected on moderate slopes whilst a greater proportion of fish (120 – 160 mm) were collected during steep slope trials.

Discussion

Fishway design considerations

Vertical slot fishways are the most widely used and successful fishway design in the world (Clay, 1995). The ability for the design to cope with fluctuating headlosses and large tailwater variations provide applicability at many different types of migration barriers (Mallen-Cooper and Stuart, 2007). The present study identified migratory fish were able to negotiate an experimental vertical slot fishway installed at a floodplain regulator on the Mekong River. The fishway provided passage for many species and size classes and offered important insights into fish behaviour that will influence the design of future fishways for the Lower Mekong Basin.

The identification of three broad migratory groups of fish suggests that Mekong species have widely varying swimming abilities and migratory cues. Fish with stronger swimming abilities readily ascended the experimental unit and were captured in relatively high abundances from the fishway exit. In contrast, fish with poorer swimming abilities were only collected under control conditions. These different scenarios suggest that whilst the construction of fishways on moderate slopes will provide good passage for most species, a proportion would still be unable to ascend. Many tropical species have different lateral migratory requirements depending on life history stage or time of year (Coops *et al.*, 2006). In tropical rivers, the use of fishways to facilitate passage is complicated by high migratory biomass, variable hydrology and higher species richness than in temperate zones. It is therefore difficult to adequately design a single fishway that can provide passage for all migratory fish into suitable habitats (Pelicice and Agostinho, 2008).

Many species of fish were observed to migrate through the experimental fishway but there were substantial differences in ascent success between control and treatment groups. Moderate slopes suited most species and size classes but there were some species which were only collected during controls or steep slope treatments. Changes in fishway hydraulics may explain some of these observed differences. Fishways with high flow and turbulence are widely understood to limit the passage of some species (Tarrade *et al.*, 2008; Liu *et al.*, 2006). This type of behaviour

was likely exhibited by the group of fish collected from control samples but absent when slope increased. High turbulence is a frequent contributor to decreased passage success and is known to disorient fish with poorer swimming abilities (Rodríguez *et al.*, 2006). This is frequently observed in large Australian rivers where inappropriate turbulence profiles in vertical slot fishways inhibit the passage of some species (Stuart *et al.*, 2008b). Under these circumstances, reducing floor slope may be a useful mechanism to increase passage of some species but the decrease in associated attraction flows would likely inhibit the passage rates of others (Lindmark and Gustavsson, 2008).

An additional solution for fish passage in this situation is the construction of multiple fishways. For instance, high slope fishways with increased discharge and attraction would provide an effective passage solution for strong-swimming species (Pon *et al.*, 2009). Providing an additional fishway with conservative hydraulics would then cater for poorer-swimming species (Stuart *et al.*, 2008b). The cumulative benefit of both structures would provide a solution that facilitates the passage of most migratory species at any given site. Cost, however, is a major limiting factor in any fishway construction exercise (Barrett and Mallen-Cooper, 2006) and constructing multiple fishways requires a high capital outlay. In the Lower Mekong Basin, such solutions would be most applicable to larger development projects with high budgets. Fish passage solutions in the Lower Mekong may therefore require a design which is low cost and provides effective passage for a majority of species within a target flow range.

Previous work has identified turbulence, and not flow, is a major limiting factor for poor swimming fish (Tarrade *et al.*, 2008; Wu *et al.*, 1999). Reductions in turbulence can be achieved through the addition of sills into the middle of each vertical slot (Mallen-Cooper *et al.*, 2008). Adding sills into fishway baffles reduces the overall slot area and overall discharge but has the added advantage of maintaining high velocities which can provide attraction. Retrofitting these devices into vertical slot fishways has been demonstrated to enhance the passage of poor swimming species, whilst still permitting the passage of stronger swimmers (Mallen-Cooper *et al.*, 2008). Experimentation with middle sills was not considered as part of the existing study but could provide substantial increases in fish passage given the differences in fish responses to altered slopes. Retrofitting sills to steep fishways would provide an inexpensive mechanism to increase functionality whilst reducing construction costs and should be considered when further developing fishway concepts for tropical rivers.

Undertaking experiments in an experimental facility provides an excellent indication of likely fishway design criteria but it cannot substitute for the construction of a permanent facility. Permanent fishways require careful design and knowledge of the local hydrology to be truly effective. A challenge for the Lower Mekong Basin is to design a vertical slot fishway which maintains functionality with large fluctuations in river level over a migration season. Engineering solutions for such a degree in water level are relatively straightforward, but it is important to note that the direct application of fishway criteria determined in this study should include careful consideration of local hydrology to ensure the most effective solution at any given site. A natural progression from this preliminary study is to therefore apply the design criteria at a permanent fishway at a floodplain regulator. A subsequent biological assessment of this structure would provide increased confidence in the ability for Vertical slot fishways to be more widely applied at other sites.

Ecology of fish migrations

Large numbers of fish were collected from many different life history stages. These fish were all migrating upstream at the regulator site and were actively attempting to access the upstream wetland. Many of these fish were riverine species, and almost all individuals were sub-adult, suggesting that many species were attempting to access nursery habitat within the upstream wetland. Tropical fish exhibit fast growth rates in floodplain habitats and many riverine (white) species are known to access floodplains for growth and development (De Graaf, 2003). Of particular note was the collection of numerous juvenile Jullien's golden carp *Probarbus jullieni*. This species has declined significantly throughout the Lower Mekong Basin and the disconnection of floodplain habitat has been a major factor in this species appearing on the IUCN red list (Baird, 2006). Collections within the experimental fishway are direct evidence that provision of fish passage may provide an important mechanism to help restore lateral connectivity of this, and other species to important nursery habitat.

This work has also substantially enhanced the understanding of the impacts of migration barriers on lateral movements between the Mekong River and its floodplain. Data provided evidence of floodplain regulators acting as a barrier to lateral migrations between the main river and floodplain habitat. The first was evidenced by the strong motivation for migratory fish to gain upstream access. Fish were extremely persistent and continually sought an upstream path but the number of migratory fish collected was strongly linked with river level. This observation provides evidence that hydrological changes provide an important cue for fish migration in the Mekong. Flows are widely reported as an important cue for fish performing both longitudinal and lateral migrations (Beyers and Carlson, 1993; Gehrke *et al.*, 1999; Humphries *et al.*, 1999; Nilsson *et al.*, 2005). Most production in large rivers occurs during periods of wetland inundation (Copp, 1989) which may account for increased attempts for fish to access floodplain habitat as water levels increased. The response to falling water levels was equally obvious. Fish that fail to quickly leave floodplain habitat during receding water levels risk becoming stranded when wetland habitat becomes disconnected (Jones and Stuart, 2008). Limiting migratory behaviour to periods of rising water levels would substantially reduce the risk of stranding and could provide an ecological explanation for reduced fishway catches during flow reductions.

Long term maintenance of river-floodplain connectivity will provide important ecological outcomes for the region. For instance, previous studies have provided a genetic basis of the importance for maintaining river-floodplain connections. For instance the identification of a single stock of Siamese mud carp *Henicorhyncus siamensis* in the lower Mekong River basin below the Khone Falls suggests that freshwater habitats in Cambodia and Vietnam are extensive and ongoing (Adamson *et al.*, 2009). However, the majority of the catch in the lower Mekong River basin is taken seasonally from localized fishing operations (Lieng *et al.*, 1995). Massive annual harvests of these and other floodplain species should contribute to stock depletion but persistence of a single stock suggests a high capacity for dispersal and connectivity among sites (Adamson *et al.*, 2009). Genetic evidence is lacking for other species but this example suggests that maintenance of migration pathways is extremely important in the Lower Mekong Basin. Providing connectivity with important floodplain habitat, through the construction of fishways, is therefore a potential mechanism to support essential life history processes necessary for the long term maintenance of both riverine and floodplain species.

Table 1. Total number of fish caught from the experimental fishway unit over the study period

Species name	Ecology	Family	Floor slope			Grand Total
			Control	1:15	1:8	
Parambassis siamensis	white	Ambassidae	819	1948	510	3277
Barbonymus gonionotus	white	Cyprinidae	160	1552	1494	3206
Rasbora dusonensis	black	Cyprinidae	1	1567	1057	2625
Barbonymus schwanenfeldii	white	Cyprinidae	0	651	9	660
Hampala dispar	white	Cyprinidae	277	249	56	582
Rasbora rubrodorsalis	black	Cyprinidae	252	248	81	581
Xenentodon canciloides	white	Belonidae	406	136	17	559
Rasbora daniconius	black	Cyprinidae	28	303	169	500
Paralaubuca typus	white	Cyprinidae	62	262	24	348
Unknown 3	-	-	320	0	0	320
Osteochilus lini	white	Cyprinidae	4	149	144	297
Esomus metallicus	black	Cyprinidae	10	181	2	193
Amblypharyngodon chulabhornae	white	Cyprinidae	179	11	0	190
Clupeichthys aesiamnesis	white	Clupeidae	155	0	0	155
Esomus longimanus	black	Cyprinidae	28	73	0	101
Osteochilus schlegelii	white	Cyprinidae	0	8	86	94
Henicorhynchus ornatipinnis	white	Cyprinidae	2	57	34	93
Unknown 2	-	-	2	15	72	89
Puntius partipentazona	white	Cyprinidae	33	2	34	69
Raiamas guttatus	white	Cyprinidae	2	37	28	67
Epalzeorhynchos fretatum	white	Cyprinidae	0	0	54	54
Hampala macrolepidota	white	Cyprinidae	22	25	1	48
Macrognathus semiocellatus	white	Mastacembelidae	46	0	0	46
Badis ruber	white	Badidae	31	10	0	41
Puntius orphoides	white	Cyprinidae	1	20	18	39
Osteochilus hasselti	white	Cyprinidae	2	11	22	35
Probarbus jullieni	white	Cyprinidae	4	22	8	34
Cephalocassis borneensis	white	Ariidae	0	32	2	34

Rasbora trileneata	black	Cyprinidae	32	1	0	33
Henicorhynchus siamensis	white	Cyprinidae	27	3	2	32
Rasbora pauciforata	black	Cyprinidae	0	21	7	28
Sinibrama melrosei	white	Cyprinidae	0	25	2	27
Mastacemblus armatus	white	Mastacembelidae	15	0	1	16
Scaphognathops stejnegeri	white	Cyprinidae	2	4	10	16
Labiobarbus siamensis	white	Cyprinidae	0	5	11	16
Macrognathus siamensis	white	Mastacembelidae	15	0	0	15
Nemacheilus platiceps	black	Nemacheilinae	12	0	2	14
Puntius jacobusboehlkei	white	Cyprinidae	0	0	10	10
Puntius brevis	white	Cyprinidae	1	9	0	10
Rasbora aurotaenia	black	Cyprinidae	0	0	9	9
Cyclocheilichthys armatus	white	Cyprinidae	0	2	6	8
Unknown 6	-	-	1	4	2	7
Barbichthys laevis	white	Cyprinidae	1	4	2	7
Acanthopsoides delphax	white	Cobitinae	4	0	1	5
Hypsibarbus vernayi	white	Cyprinidae	1	2	2	5
Pristolepis fasciata	white	Nandidae	1	2	1	4
Oreochromis niloticus	black	Cichlidae	3	1	0	4
Amblyrhynchichthys truncatus	white	Cyprinidae	0	2	2	4
Acanthopsis spp	black	Cobitidae	4	0	0	4
Hemibarbus labeo	white	Cyprinidae	1	2	1	4
Scaphognathops spp	white	Cyprinidae	1	2	1	4
Cyclocheilichthys repasson	white	Cyprinidae	0	1	2	3
Anabas testudineus	black	Anabantidae	3	0	0	3
Unknown 7	-	-	3	0	0	3
Cyclocheilichthys apogon	white	Cyprinidae	0	0	3	3
Unknown 1	-	-	1	0	2	3
Trichogaster microlepis	black	Osphronemidae	3	0	0	3
Thynnichtys thynnoides	white	Cyprinidae	0	0	3	3
Brachygobius mekongensis	white	Gobionellinae	2	0	0	2
Chitala ornata	white	Notopteridae	0	2	0	2

Barbonymus altus	white	Cyprinidae	0	2	0	2
Mystus mysticetus	white	Bagridae	1	0	1	2
Cyprinus carpio	white	Cyprinidae	0	1	1	2
Notopterus notopterus	white	Notopteridae	0	0	2	2
Labiobarbus leptocheilus	white	Cyprinidae	1	0	0	1
Squalidus atromaculatus	white	Cyprinidae	1	0	0	1
Nandus oxyrhynchus	black	Nandidae	1	0	0	1
Unknown 4	-	-	1	0	0	1
Hypophthalmichthys molitrix	white	Cyprinidae	0	0	1	1
Yasuhikotakia longidorsalis	black	Botiinae	0	1	0	1
Unknown 8	-	-	1	0	0	1
Acrossocheilus iridescens	white	Cyprinidae	1	0	0	1
Tetradon cambodgiensis	white	Tetraodontidae	0	1	0	1
Grand Total			**2986**	**7666**	**4009**	**14661**

Numbers refer to all species pooled across blocks for all experimental controls and treatments performed.

Table 2. PERMANOVA results for differences in fish community structure among factors assessed during the experimental study

Effect	df	SS	MS	Ps-F	P
Among Blocks	5	25,498	5,099	1.77	0.015
Slopes (Blocks)	12	24,502	2,041	1.94	0.001
Time of Day (Blocks)	12	12,911	1,075	1.03	0.416
Blocks X slope X time of day	14	14,496	1,035	1.07	0.404

df refers to degrees of freedom, SS is sum of squares, MS is mean squares, PS-F is the Psuedo-F value and P is the probability based on multiple permutations of the data

Table 3. Length statistics for species captured within the experimental fishway facility. For brevity, only species with 10 or more individuals have been included

Species name	Family	n	Mean ± SD	Min	Max
Amblypharyngodon chulabhornae	Cyprinidae	94	34±7	20	75
Badis ruber	Badidae	31	35±5	25	45
Barbonymus gonionotus	Cyprinidae	643	61±16	29	116
Barbonymus schwanenfeldii	Cyprinidae	36	45±10	31	80
Clupeichthys aesiamnesis	Clupeidae	25	37±4	30	45
Esomus longimanus	Cyprinidae	72	54±9	40	80
Esomus metallicus	Cyprinidae	92	53±9	34	75
Hampala dispar	Cyprinidae	358	44±11	25	127
Hampala macrolepidota	Cyprinidae	48	38±9	25	75
Henicorhynchus ornatipinnis	Cyprinidae	93	67±12	35	115
Henicorhynchus siamensis	Cyprinidae	30	36±25	20	125
Labiobarbus siamensis	Cyprinidae	14	91±12	70	111
Macrognathus semiocellatus	Mastacembelidae	46	138±20	100	176
Macrognathus siamensis	Mastacembelidae	15	145±34	42	191
Mastacemblus armatus	Mastacembelidae	16	130±37	65	200
Nemacheilus platiceps	Nemacheilinae	14	48±13	33	78
Osteochilus hasselti	Cyprinidae	32	127±25	95	195
Osteochilus lini	Cyprinidae	201	105±17	19	145
Osteochilus schlegelii	Cyprinidae	51	106±10	81	134
Paralaubuca typus	Cyprinidae	235	50±7	29	87
Parambassis siamensis	Ambassidae	945	46±8	24	92
Probarbus jullieni	Cyprinidae	36	69±9	50	84
Puntius jacobusboehlkei	Cyprinidae	10	155±24	132	195
Puntius orphoides	Cyprinidae	39	56±7	45	85
Puntius partipentazona	Cyprinidae	20	34±3	28	41
Raiamas guttatus	Cyprinidae	69	61±12	42	111
Rasbora aurotaenia	Cyprinidae	25	79±7	64	90
Rasbora daniconius	Cyprinidae	412	60±10	22	96
Rasbora dusonensis	Cyprinidae	618	76±10	24	105
Rasbora rubrodorsalis	Cyprinidae	351	36±9	21	79
Scaphognathops stejnegeri	Cyprinidae	17	46±6	35	62
Xenentodon cancilloides	Belonidae	452	158±40	20	285

n refers to the total number of fish measured, mean ± SD refers to the mean of all measured fish and one standard error, min is the smallest fish measured and max is the largest fish measured.

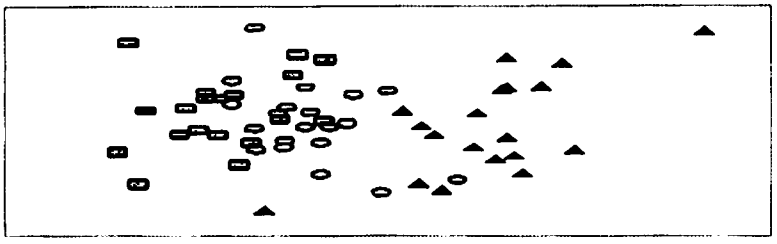


Figure 1. Multidimensional scaling ordination of fish communities captured during control (black triangle), 100 mm (white circle) and 200 mm (grey square) treatments assessed during this study

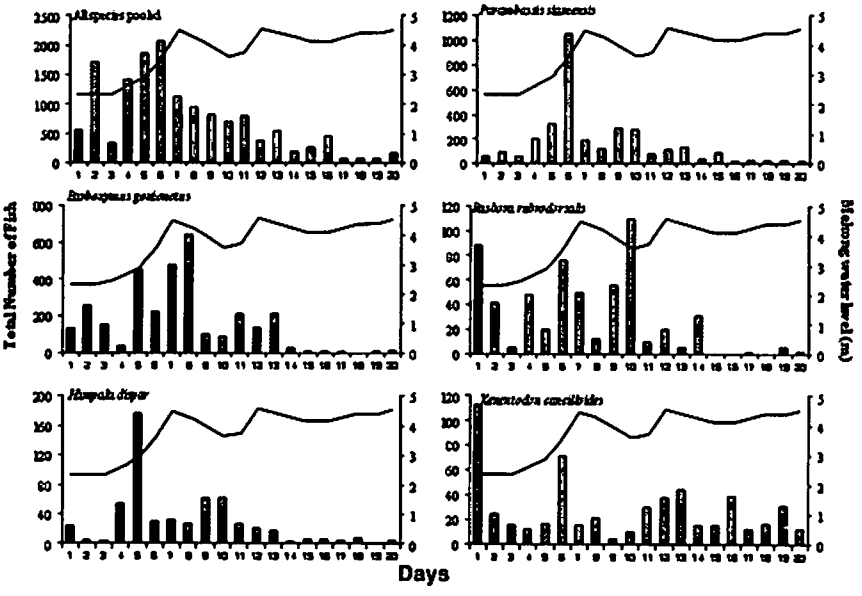


Figure 2. Relationship between daily fish catches and Mekong River level over the study period. Data is only presented where fishway trapping was conducted on consecutive days

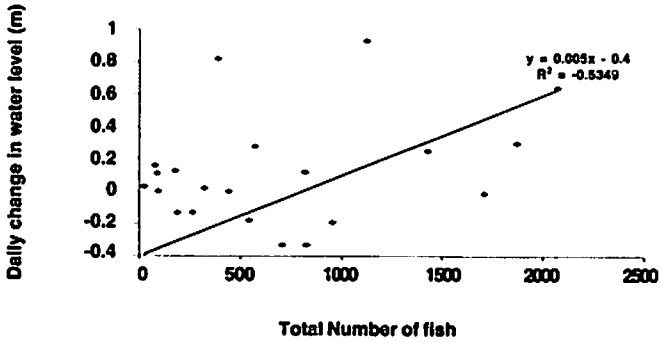


Figure 3. Scatterplot of the relationship between change in water level and migratory fish movements

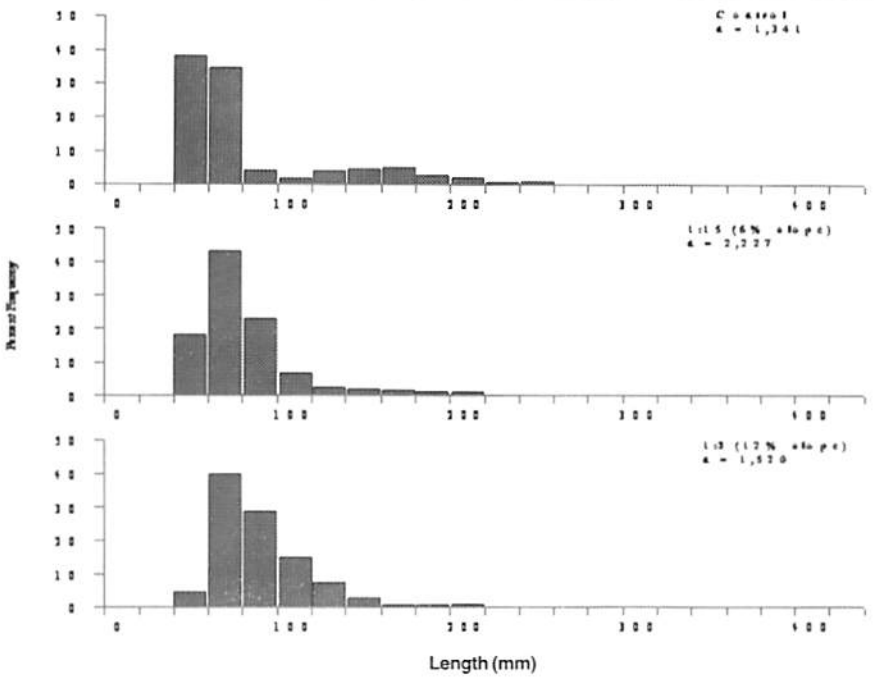


Figure 4. Length distributions of fish collected in each experimental treatment and control. Values are pooled across all species and experimental blocks

Refferences

Andersen J T, Watry C B and Gray A. 2007. Upstream fish passage at a resistance board weir using infrared and digital technology in the lower Stanilaus River, California. (Gresham: Cramer Fish Sciences) p 33.

Baird I G. 2006. Probarbus jullieni and Probarbus labeamajor: the management and conservation of two of the largest fish species in the Mekong River in southern Laos *Aquatic Conservation: Marine and Freshwater Ecosystems* 16 517-32.

Barrett J and Mallen-Cooper M. 2006. The Murray River's 'Sea to Hume Dam' fish passage program: Progress to date and lessons learned *Ecological Management & Restoration* 7 173-83.

Baumgartner L J and Harris J H. 2007. Passage of non-salmonid fish through a Deelder lock on a lowland river *River Research and Applications* 23 1058-69.

Bayley P B. 1995. Understanding Large River: Floodplain Ecosystems *BioScience* 45 153

Beyers D W and Carlson C A. 1993. Movement and habitat use of triploid grass carp in a Colorado irrigation canal *N. Am. J. Fish. Manage.* 13 141-50.

Bunt C M. 2001. Fishway entrance modifications enhance fish attraction *Fisheries Management and Ecology* 8 95-105.

Campbell I C . 2005. *Intergrated Water Resources Management in South and South-East Asia*, ed A K Biswas, *et al.* (New Delhi: Oxford University Press) p 353.

Clay C H . 1995. *Design of fishways and other fish facilities* (Boca Raton: CRC-Press).

Coops H, Tockner K, Amoros C, Hein T and Quinn G. 2006. *Wetlands and Natural Resource Management*, ed T A Verhoeven, *et al.* pp 15-32.

Copp G. 1989. The habitat diversity and fish reproductive function of floodplain ecosystems *Environ. Biol. Fish.* 26: 1-27.

De Graaf G J. 2003. The Flood Pulse and Growth of floodplain fish in Bangladesh *Fisheries Management and Ecology* : 10.

Fernando Mayer P and Angelo Antonio A. 2008. Fish-Passage Facilities as Ecological Traps in Large Neotropical Rivers *Conservation Biology* 22: 180-8.

Gehrke P C, Astles K L and Harris J H. 1999. Within-catchment effects of flow alteration on fish assemblages in the Hawkesbury-Nepean River system, Australia *Regulated Rivers: Research & Management* 15: 181-98.

Hamano T, Yoshimi K, Hayashi K I, Kakimoto H and Shokita S. 1995. Experiments on fishways for freshwater amphidromous shrimps *Nippon Suisan Gakkaishi* 61: 171.

Hortle K G. 2007. Consumption and the yield of fish and other aquatic animals from the lower Mekong basin *MRC Technical Paper* 16: 1-88.

Hortle K G, Troeung R and Lieng S. 2008. Yield of the wild fishery of rice fields in Battambang Province, near the Tonle Sap Lake, Cambodia *MRC Technical Paper* 18: 1-62.

Humphries P, King A J and Koehn J D. 1999. Fish, flows and floodplains: links between freshwater fishes and their environment in the Murray-Darling River System, Australia. *Environ. Biol. Fish.* 56: 129-51.

Islam M and Braden J B. 2006. Bioeconomic development of floodplains: farming versus fishing in Bangladesh *Environment and Development Economics* 11: 95-126.

Jones M J and Stuart I G. 2008. Regulated floodplains - a trap for unwary fish *Fisheries Management and Ecology* 15: 71-9.

Jorgensen J V and Poulsen A F. 2000. Using local knowledge as a research.

Junk W J, Bayley P B and Sparks R E 1989 The Flood Pulse Concept in River-Floodplain Systems. In: *Proceedings of the International Large Rivers Symposium Canadian Special Publication in Fisheries and Aquatic Science,* ed D P Dodge pp 110-27.

King C and Torre A. 2007. Reconnecting off-channel habitats to waterways - using engineering techniques to restore fish passage. In: *WA Wetland Management Conference,* (Cockburn: Department of Water, Western Australia).

Kingsford R T. 2000. Ecological impacts of dams, water diversions and river management on floodplain wetlands in Australia *Austral Ecology* 25: 109-27.

Kowarsky J and Ross A H. 1981. Fish movement upstream through a central Queensland (Fitzroy River) coastal fishway *Marine and Freshwater Research* 32: 93-109

Kummu M, Koponen J and Srkkula J. 2005. Assessing the Impacts of the Mekong Development in the Tonle Sap Lake. In: *Role of Water Sciences in Transboundary River Basin Management,* (Thailand: Mekong River Commission) pp 89-98.

Lieng S, Yim C and Van Zalinge N. 1995. Freshwater fisheries of Cambodia, I: the Bagnet (Dai) fishery in the Tonle Sap River. *Asian Fisheries Science* 9: 258-65.

Lindmark E and Gustavsson H. 2008. Field study of an attraction channel as entrance to fishways *River Research and Applications* 24: 564-70.

Liu M, Rajaratnam N and Zhu D Z. 2006. Mean Flow and Turbulence Structure in Vertical Slot Fishways *J. Hydraul. Eng.* 132: 765-77.

Lowe-McConnell R H. 1987. *Ecological studies in Tropical Fish Communities* (Cambridge: Cambridge University Press).

Lu X X and Siew R Y. 2006. Water discharge and sediment flux over the past decades in the Lower Mekong River: possible impacts of the Chinese Dams *Hydrology and Earth System Sciences* 10: 181-95.

Mallen-Cooper M. 1996. Fishways and freshwater fish migration in South-Eastern Australia. (Sydney: University of Technology) p 429.

Mallen-Cooper M and Brand D M. 2007. Non-salmonids in a salmonid fishway: what do 50 years of data tell us about past and future fish passage? *Fisheries Management and Ecology* 14 : 319-32.

Mallen-Cooper M and Stuart I G. 2007. Optimising Denil fishways for passage of small and large fishes *Fisheries Management and Ecology* 14 : 61-71.

Mallen-Cooper M, Zampatti B P, Stuart I G and Baumgartner L J. 2008. Innovative Fishways - Manipulating turbulence in the vertical-slot design to improve performance and reduce cost (Sydney: Fishway Consulting Services) p 19.

Nguyen T T T and De Silva S S. 2006. Freshwater finfish biodiversity and conservation: an asian perspective *Biodiversity and Conservation* 15 : 3543-68.

Nilsson C, Reidy C A, Dynesius M and Revenga C. 2005. Fragmentation and Flow Regulation of the World's Large River systems *Science* 308 : 405-8.

Odeh M. 1999. *Innovations in fish passage technology* (Bethedsa: American Fisheries Society) slot fishways *Hydrobiologia* 609 : 177-8.

Pagdee A, Homchuen S, Sangpradab N, Hanjavanit C and Uttharak P. 2007. Biodiversity and economic value of wetland resources at Nong Han, Udonthani Province, Northeast Thailand *Natural History Bulletin of the Siam Society* 55 : 323-39.

Pelicice F M and Agostinho A A. 2008. Fish-Passage Facilities as Ecological Traps in Large Neotropical Rivers *Conservation Biology* 22 : 180-8.

Pon L B, Hinch S G, Cooke S J, Patterson D A and Farrell A P. 2009. A Comparison of the Physiological Condition, and Fishway Passage Time and Success of Migrant Adult Sockeye Salmon at Seton River Dam, British Columbia, under Three Operational Water Discharge Rates *N. Am. J. Fish. Manage.* 29 : 1195-205.

Rodríguez T T, Agudo J P, Mosquera L P and González E P. 2006. Evaluating vertical-slot fishway designs in terms of fish swimming capabilities *Ecological Engineering* 27 : 37-48.

Roscoe D W and Hinch S G. 2009. Effectiveness monitoring of fish passage facilities: historical trends, geographic patterns and future directions *Fish and Fisheries* In Press 22.

Schmetterling D A, Pierce R W and Liermann B W. 2002. Efficacy of three Denil fish ladders for low-flow fish passage in two tributaries to the Blackfoot river, Montana *N. Am. J. Fish. Manage.* 22 : 929-33.

Schwalme K and Mackay W C. 1985. Suitability of vertical slot and Denil fishways for passing north-temperate, nonsalmonid fish *Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.* 42 : 1815-22.

Sparks R E. 1995. Need for Ecosystem Management of Large Rivers and Their Floodplains *BioScience* 45 : 168-82.

Sripatrptasite P. 2005. Effects of fish ladder on migratory fish species and fisheries at Pak Mun Dam. (Bankok: Asian Institute of Technology) p 245.

Stuart I G, Baumgartner L J and Zampatti B P. 2008. Lock gates improve passage of small-bodied fish and crustaceans in a low gradient vertical-slot fishway *Fisheries Management and Ecology* 15 : 241-8.

Stuart I G, Berghuis A P, Long P E and Mallen-Cooper M. 2007. Do fish locks have potential in tropical rivers? *River Research and Applications* 23 : 269-86.

Stuart I G and Mallen-Cooper M. 1999. An assessment of the effectiveness of a vertical-slot fishway for non-salmonid fish at a tidal barrier on a large tropical/subtropical river *Regulated Rivers: Research & Management* 15 : 575-90.

STUDY ON PAST AND CURRENT FARMING SYSTEMS IN LE PYIN THAR VILLAGE, YAMETHIN TOWNSHIP

Theingi Myint[1]

Abstract

The overall objective of the study is to examine the changes of farming system during the last 60 years in Yemethin area. Primary data were collected by interviewing 42 sampled farmers who were over 59 years with a structure questionnaire at Le Pyin Thar village, one of the most diversified cropping areas in Yemethin Township. Descriptive statistic was used to examine the differences between past and current farming systems. The findings of the study showed that land holding size of sample farmers became small during 1949-2009. Cropping pattern was also more diversified over time. Most of the farmers used local crop varieties for a long time, and usage of improved crop seed and source of seed procurement were not much changed. Weed control was also not much improved, and hand weeding was the major weed control method. However, the usage of chemical fertilizers was dramatically increased over time. Using amount of organic manure became less. The threshing machine was used more than over the last 20 years. The major constraint of sample farmers for cultivation was policy restriction on crop choice, low crop price and inadequate investment for their farming activities.

Key Words : Orchard rice based cropping patterns, organic manure , crop diversification

Introduction

Farming is the major employer of masses in the dry zone area, representing nearly 30% of the population. Presently, there are very limited alternative sources of employment available in the dry zone. The productivity of the farming system has declined and partial crop failures due to drought are common. This wide spread land degradation is in effect caused by the inappropriate agricultural practices. The renewable natural resources are being depleted more rapidly than the nature can renew. Despite the environmental, technical and financial difficulties being faced by the farmers, their approach to farming is very much entrepreneurial.

Yamethin Township stretches about 906 miles from north to south and about 836 miles from east to west. It is comprised of 67 village tracts. It stands from North latitude 202 102 to 202 352 and East latitude 952 402 to 962 302 . There are one dam and two lakes. Yamethin district includes rolling uplands and foothills of Bago Yoma in the West, central plain in the center and mountains of Shan Plateau in the East. The numerous streams are flowing down from different directions in all parts of the area. In the north, Chaungmagyi stream, Thitson stream, Shweda stream and Nawin stream are prominent (MAS 2005).

Yamethin District is considered under the intermediate dry zone, having only 3 months with rainfall exceeding monthly evapo-transpiration. Soil moisture retention is low and vegetation cover is thin. Mostly drought resistant variety of crops such as cotton, pigeon pea, sesame, sorghum, maize are grown often mixed or relay cropping to make efficient use of soil moisture (Khaing Khaing Htwe, 2006).

1. Lecturer, Department of Agricultural Economics, Yezin Agricultural University, Myanmar

The net cultivated area is 288,326 ha according to the record of Yamethin District Agricultural Office. It is occupying 26.5% of the total land area in the Yamethin District. About 72% of cultivated land is paddy land and others are garden land. Based on the nature of land and farming methods, the current cultivated land is classified as paddy land, low land, rainfed low land (le), dry land, upland (ya), garden and orchard (Thet, 2003). Upland (ya) occupy the largest position of the district. The area under garden and shifting cultivation is very small. The central plain, both sides of road and railway track is the lowland paddy field (le), cultivating rainfed rice or irrigated rice. There are three seasons for crop cultivation, pre- monsoon, monsoon and post-monsoon (Thet, 2003).

The dominant cropping pattern is rice based cropping pattern. Most of the first crop is rice and second crop is summer rice. Cropping pattern is varied according to changes of environmental factors and topographical factors. In rice – legumes system, farmers grow only chickpea or black gram after rainy season rice because sesame is risky where rain is scarce in some regions. However, some non – irrigated area and dry areas are left as fallow during the summer season. Small farm machineries such as hand tractors, water pumps, engines etc have been introducing into farming. At present, Myanmar Mechanical Farm Department (MMFD) provides mechanical tillage and other mechanical and technical assistances for farmer's fields (Khaing Khain Htwe, 2006).

Results and Discussion

Demographic characteristics of sample farmers in study area

Among the sample farmers, the eldest was 91 years old, the youngest was 59 years old and average was 75 years old. For all sample size, the maximum, minimum and average work experience were 76 years, 20 years and 49 years respectively. Average family size was 6, ranging from maximum 13 and minimum 2. For the whole sample, the maximum and minimum family labours on their farm were 10 and 2 respectively, and average family labor was 5. Moreover, average schooling family member was 3 and it was ranged from 2 to 5 (Table 1).

Table 1. Demographic characteristic of respondents in survey area

Character	Maximum	Minimum	Average
Age (year)	91	59	75
Year of work experience	76	20	49
Total family size	13	2	6
Family labor	10	2	5
Schooling family member	5	2	4

By observation the educational level, it was found that all respondents were literate and about one third of them had middle school level education (Table 2).

Table 2. Education level of sample respondents

No.	Education	%
1	Monastery	38
2	Primary	24
3	Middle	35.7
4	Graduated	2.3
	Total	**100**

Average farm size of lowland and upland were not much different since the sample farmers owned 3 acres of lowland and 2.3 acres of upland farms. Maximum acre of lowland was two times larger than the upland farm (22 and 11 acres). Average garden farm size was 1.8 acres, ranging from 0.2 to 4 acres (Table 3).

Table 3. Farm size and current type of farm

Farm Type	Maximum (acre)	Minimum (acre)	Average (acre)
Lowland	22	1	3.0
Upland	11	0.5	2.3
Garden	4	0.2	1.8

Table 4 presents sources of water for farm in the study area. Among the sample farms, 12.5 % of lowland farm were rain-fed area while 87.5 % of lowland were irrigated from Kinda Dam. Half of upland farms relied on rain and the rest were grown by irrigated water supplied from owned wells.

Table 4. Sources of available water for lowland and upland farms

Rain-fed (%)	Irrigation (%)	Total	(%)
Lowland	12.5	87.5	100
Upland	50	50	100

The sample farmers in the study area grew rice, cotton, chickpea, chili, green gram, corn, betel, grape, egg plant, sunflower, flower, bitter guard, sesame, coriander, mango, banana, indigo, snake pea, French pea, ,cluster bean, pigeon pea, winged pea, bottle guard, and other seasonal crops. Among them, rice was grown as mono-crop by 24% of farmers while green gram, pigeon pea, corn, grape, French pea, betel, and seasonal crops were also grown by few farmers (Table 5).

Table 5. Different kind of mono-crops in the study area

Mono-cropping Patterns	Sample Farmers%
Rice	24
Green gram	5
Pigeón pea	5
Corn	2
Grape	5
French pea	2
Betel Other patterns	255
Total	**100**

In Table 6 major double cropping pattern, rice-green gram was grown by 31.3% of respondents. Rice - sunflower pattern was practiced by 10 % of them. Legume crops such as green gram and wing pea were commonly grown after cotton, sunflower, sesame and bitter gourd (5% for each). Two kinds of legume crops were also grown as double cropping.

Table 6. Double cropping pattern

Double Cropping Patterns	Sample Farmers (%)
Rice – Green gram	31.3
Rice – Sunflower	10
Green gram – Cotton	5.3
Green gram – Sunflower	5.3
Green gram - Sesame	5.3
Sesame – pigeon pea	5.3
Sesame – Chili	5.3
Egg plant – French pea	10.6
Wing pea – Bitter guard	5.3
Wing pea – French pea	5.3
Cluster bean – French pea	5.3
Seasonal crop – Egg plant	5.3

Majority of farmers (34%) intercropped sunflower with green gram and sesame (34% for each cropping). Some practiced corn based intercropping with sunflower and sesame (16%) (Table 7).

Table 7. Inter cropping pattern in the study area

Inter Cropping Patterns	Sample Farmers (%)
Green gram – Sunflower	34
Sunflower - Corn	16
Sesame – Corn	16
Sesame - Sunflower	34
Total	**100**

High yielding varieties have been using by the sample farmers in growing rice (65%), green gram (33%), pigeon pea (50%) and betel (28%). All farmers used improved variety of grape. The rest of crops were still local varieties (Table 8).

Table 8. Type of crops seed in survey area

Type of Crop	HYV (%)	Local variety (%)
Rice	65	35
Green gram	33	67
Betel	28	72
Pigeon pea	50	50
Grape	100	-

Different kinds of fertilizers and manure such as urea, t-super, potash compound fertilizer, farm yard manure were used for rice, green gram, French bean, betel, grape and egg plant. More than 50% to 75% of farmers usually applied urea for their mentioned crops. T super was used by 50%, 33%, 28%, 25%, 18%, 12% of farmers for sesame, French bean, rice, grape, betel and green gram respectively. All farmers used FYM in pigeon pea. For betel compound and potash were applied by 5% of farmers respectively (Table 9).

Table 9. Different kinds of fertilizer and manure for growing crops

Type of Fertilizer	Rice	Green gram	Betel	Grape	French pea	Egg plant	Sesame
Urea	53%	63%	63%	75%	67%	67%	50%
T-Super	28%	12%	18%	25%	33%	-	50%
FYM	10%	25%	-	-	-	-	-
Compound	10%	-	5%	-	-	-	-
Potassium	-	-	5%	-	-	-	-
Nil	-	-	9%	-	-	33%	-

Almost all of the farmers employed hand weeding in all crops. In rice and green gram cultivation 12% and 14% of respondents respectively used inter-cultivation for weed control. There were 44% of rice farmers and 50% of pigeon pea growing farmers did not used any weed control method in study area (Table 10).

Table 10. Methods of weed control

Methods	Rice	Green gram	Pigeon pea
Hand Weeding	44%	86%	50%
Inter-cultivation	12%	14%	-
Nil	44%	-	50%

Changes of farming practices in study area

To learn the past experiences of their farming system, the study have collected the data for 10 years interval. Figure 1shows that average land holding size was decreasing from 5.16 acres to nearly 3 acres within 60 years.

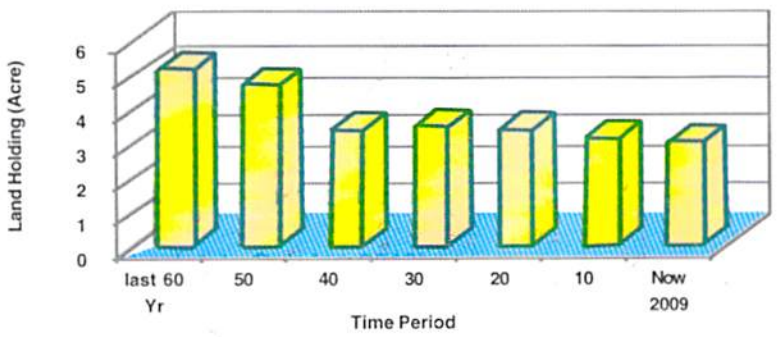


Figure 1. Average land holding of sample farmers

According to the Figure 2, 90% of sample farmers were still growing local varieties for all crops. There was no difference of using high yielding variety for over 60 in the study area.

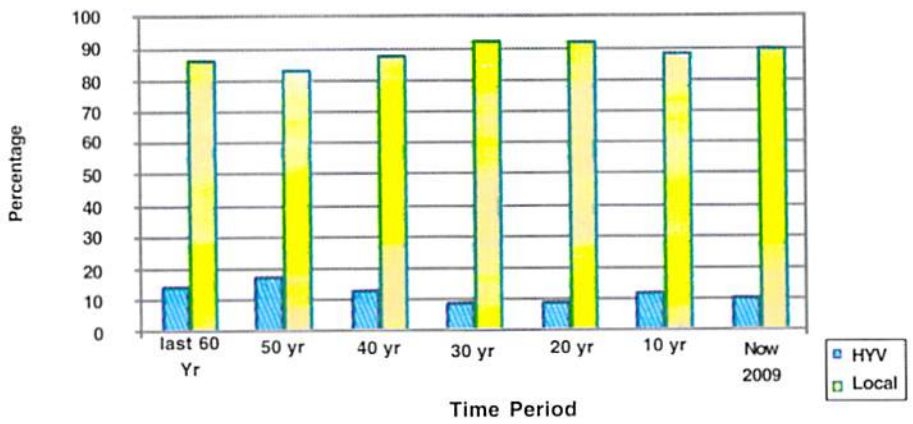


Figure 2. Type of growing seed for long time

Generally, crop seeds were obtained by gradually more purchasing by the majority of farmers (about 80%), while storing seeds for sowing system was decreased from about 30 to 20%. Purchasing seeds by credit system was done by 10% of farmers and it was continuously decreased (Figure 3).

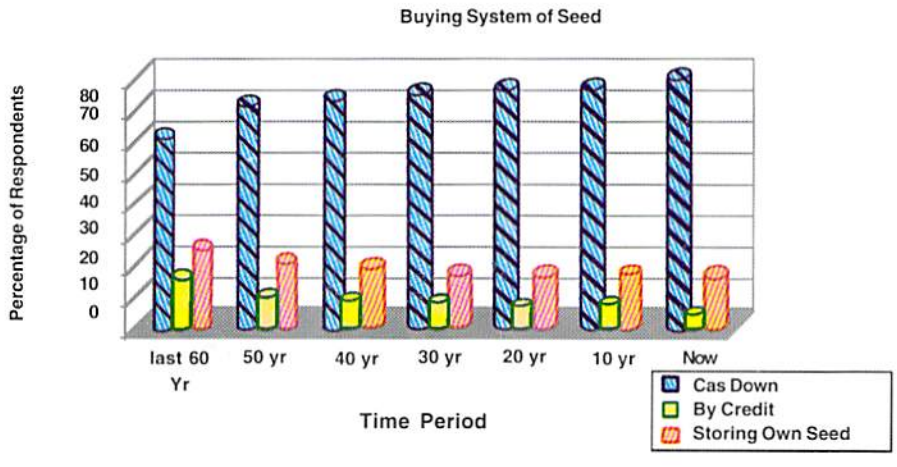


Figure 3. Procurement of seeds during 1949 to 2009

According to the Figure 4, nearly all of the sample farmers employed hand weeding in the past 60 years ago. Starting from the last 10 years, few farmers used inter-cultivation method for weed control on their farms.

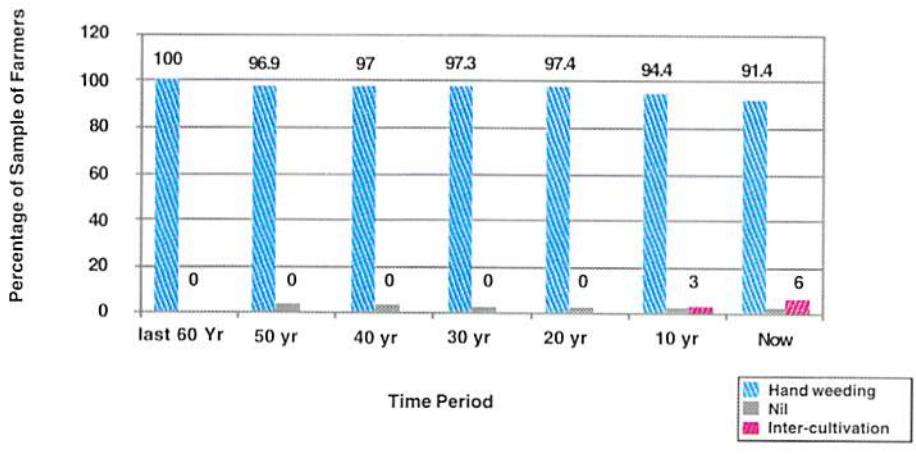


Figure 4. Weed control methods

In the last 60 years, most farmers preferred to use manure fertilizer (59%) than chemical fertilizer (27%). Any manure was not used by 14% of the farmers. But, chemical fertilizer application was increasingly used and in 2009, 90% of sample farmers were applying fertilizers. Organic manure was applied by 7.6% only in the study area (Figure 5).

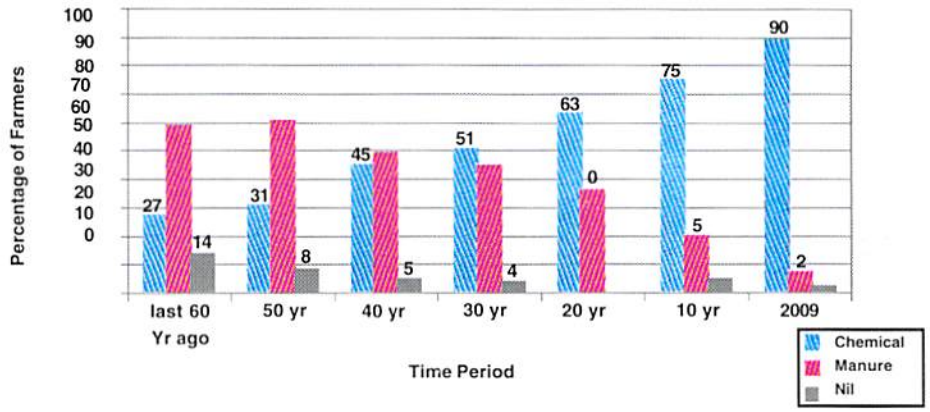


Figure 5. Type of fertilizer application during 60 years

According to the responses of 90% of sample farmers, soil fertility was in good condition in the past 30 to 60 years ago. But the farmers had negative view on the current soil condition due to the applications of chemical fertilizers in place of natural manure. Figure 6 shows very clearly positive and negative views (50:50) on their farm soil fertility during the study period (Figure 6).

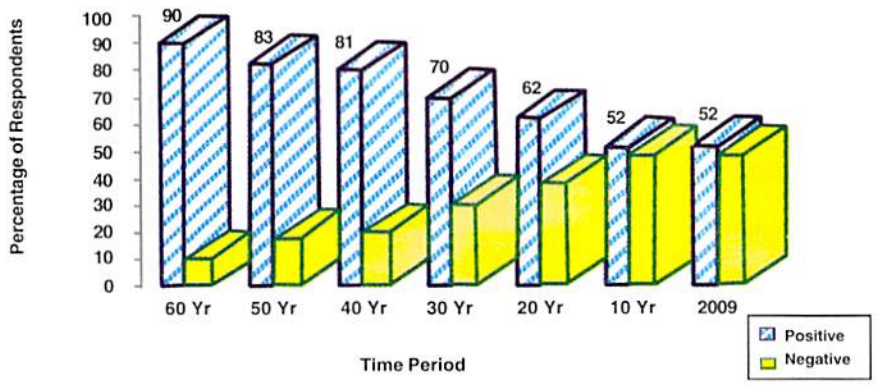


Figure 6. Opinion of soil condition adverse effect of chemical fertilizer

In case of insecticides application, 78% of farmers never used insecticides in the last 60 years. But some farmers applied traditional insecticides within the recent 10 years. Application of chemical insecticides was increasing from 22% to 93% within 60 years (Figure 7).

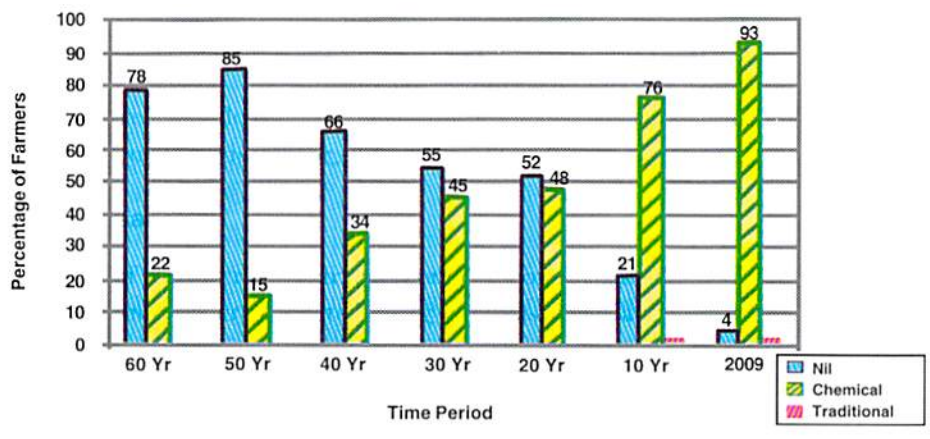


Figure 7. Type of insecticides

Since 60 years ago, harvesting was done by hand for all kinds of crops. In last 60 years, threshing for rice was totally done by animal power. After that, threshing was done by hand as well. Threshing machine for rice has been used increasingly since 20 years ago in study area (Figure 8).

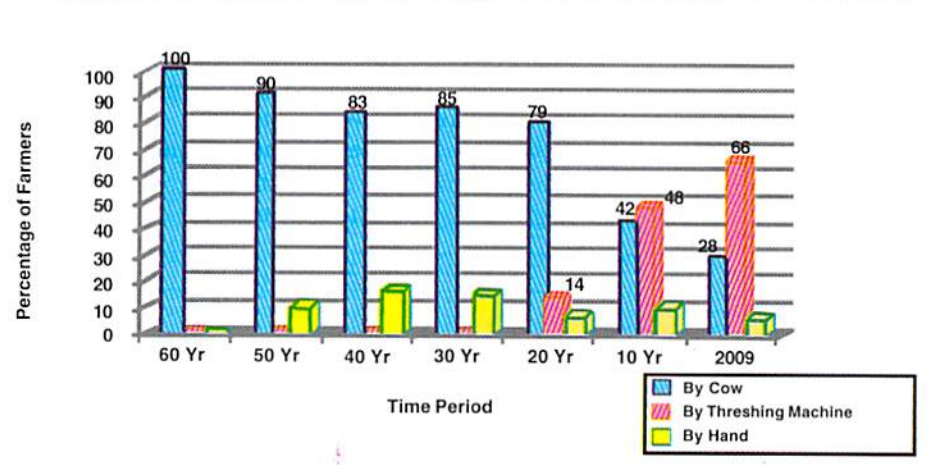


Figure 8. Type of threshing

During 60 years period, farmers needed loan for their farm. Table 11 shows the accessible of private loan for sample farmers. From 60 years ago to now, loan from local money lenders was found to be increasing trend from 7 to 48%. Farmers needed more and more loan money from private money lenders because formal credit system could not provide enough amount of loan in the study period.

Table 11. Accessible of Local Private Loan for Sample Farmers

Loan	60 yr	50 yr	40 yr	30 yr	20 yr	10 yr	Present
Yes (%)	7	13	28	39	40	48	44
No (%)	93	87	72	61	60	52	56

Table 12 shows the main problem faced by the sample farmers in the 60 years period was the decisions of crop production which was restricted by governmental institutions. Other important problem was credit unavailability which was increased from about 50% in 40 years ago to 87% at the present. Lack of technology and low-fixed crop prices were also more serious than before. Unavailability of hired labor and local private loan were also found as problems.

Table 12. Problems faced by sample farmers in the study period

No	Problem faced by respondents	60 yrs	50 yrs	40 yrs	30 yrs	20 yrs	10 yrs	Present (2009)
1	Policy restriction	50	55	54	50	62	71	68
2	Unavailability of Credit	34	39	49	70	73	86	87
3	Lack of Technology	29	33	39	43	42	44	60
4	Adverse Climate	20	24	29	45	58	30	44
5	Low Crop Prices	20	24	28	33	33	35	69
6	Unavailability of Hired Labor	17	18	24	43	52	48	47
7	Unavailability of Private Loan	17	7	7	18	22	26	27
8	Unavailable water	23	39	38	30	32	21	20
9	Unavailable H Y V	0	0	10	10	5	14	15

Conclusion

Since the study area is surrounding with many streams and dam agriculture can be worked with irrigation and many different double cropping as well as intercropping patterns at the present situation. Farm size was decreased due to many reasons needed to find out to know the effect of decreased farm size. Utilization of improved crop variety for their major crops, fertilizer and insecticide applications, inter-cultivation practice in rice and green gram, and threshing machines for rice harvesting process were evidently increased within 60 years period. The development of improved agricultural practices and cropping patterns can be increased if policy restriction on crop cultivation, credit needs and low price of crops are solved by agricultural authorities concerned.

References

Khaing Khaing Htwe. 2006. Sustainability Assessment of Rice- based cropping system in Yamethin District, Myanmar, Master of Science (Agriculture) in Agricultural system.

Ministry of Agriculture and Irrigation (MOAI). 2005. Official records, 2005.

Myanmar Journal of Agricultural Sciences MJAS. 1994. Vol.6, No.1, Yangon, Myanmar

Thet, K.K. 2003. Rice and Sugarcane Acerage estimation on Yamethin District, using GIS and Remote Sensing technique. Master's thesis, Centre Space Science Technology Education for Asia and the pacific (CSSTE/AP) affiliate by UN, India.

SUSTAINABILITY OF DIVERSIFIED FARMS IN YAMETHIN TOWNSHIP, MANDALAY REGION

Khin Oo[1] and May Thu Zar Moe[2]

Abstract

The study was conducted to get information relevant to the evaluation of diverse cropping systems and explore the sustainability of different cropping systems in the Yamethin area during 2009 February to June. The survey was conducted by personally interviewing 114 farmers to collect the primary data using a structured questionnaire. Secondary data were collected from the offices of township and district Myanma Agriculture Services.

The economic viability was found to be highest in 'wetland + dryland + garden' system. The system wise analysis revealed that the ecological soundness of the wetland + dryland + garden and wetland + dryland systems were the highest, followed by wetland + garden system. It is evident that the sustainability levels of wetland + dryland, wetland + garden and wetland + dryland + garden were found to have high level of sustainability. Diversified farm including wetland based cropping system showed higher economic viability, ecological soundness and sustainability.

Key Words : Sustainable agriculture, diversified farms wetland, dryland, garden crops

I. Introduction

Agriculture not only significantly affects the environment but is also impacted directly by changing in the environment. The social and economic impacts of environmental changes are also significant in many developing countries as agriculture is the major source of livelihood support (Rao and.Rogers 2006). Agricultural diversification can serve as a strategy for simultaneously promoting poverty reduction, economic development and environmental sustainability in poor regions (Angelsen & Kaimowitz, 2001).

A precise definition of sustainable agriculture is an adherence to the principles that include improving productivity, profitability, conserving resources, protecting the environment, and finding socially acceptable systems that sustain both farmers and rural communities. Sustainability is to help farmers develop more ecologically sound and economically viable farming systems with existing technology. Diversified systems are less input-dependent and thus tend to be more ecologically sound than specialized systems of farming. However, diversified farms are generally considered to be less productive and thus may be less profitable than more specialized systems.

1. Professor, Yezin Agricultural University, Myanmar
2. M. Sc Student, Yezin Agricultural University, Myanmar

There is a wide range of empirical work on assessing agricultural sustainability at the farm and regional levels through use of diverse indicators (Rao and Rogers 2006).

In Myanmar, the development of national economy is highly reliant in agriculture. Agriculture plays primary role for food self-sufficiency in national food requirement because the population of the country is estimated about 52 millions with annual growth rate 1.84% and raw material requirement for industry sector and export (Ellis, 1998).

An increase in population and the expansion of infrastructure in the central part of Myanmar has resulted in non-sustainable use of natural resources. Also, land has been used intensively for agricultural purposes and the use of chemical fertilizer and pesticides has increased tremendously. Moreover, farmers' existing agricultural systems have changed in favor of market-oriented systems. Therefore, there is an urgent need to study the conditions of sustainable farming systems in the central areas of Myanmar.

Objectives

The study was conducted with two objectives:

1. to get information relevant to the evaluation of diverse cropping systems
2. to explore the sustainability of different cropping systems in the Yamethin Township

II. Reserach Methodology

2.1. General description of the study area

The Yamethin district, having an elongated shape from north to south, is situated in the central part of the Union of Myanmar. It is bounded approximately between longitude 95^0 35' E and 96^0 42 'E latitude 19^0 25' N and 20^0 47' N. The district extends about 141km from north to south and about 77km from east to west. Total area of study area is about 108,828 sq-km or1, 088,289 ha. Yamethin District is considered under the intermediate dry zone (*Transition zone*), having only three months with rainfall exceeding monthly evapotranspiration.

2.2. Data source and sampling method

The survey was done from February to June 2009. There are 67 village tracts in Yamethin Township. One hundred and fourteen farmers were sampled from 8 village tracts. Primary data were collected at the household level with structured questionnaire. The secondary data of agro-climatic data, total cultivated area, production and yield were obtained from different internet website and Myanmar Agriculture Service (MAS) in Yamethin.

2.3. Data analysis

The data from structured interview were used to evaluate the economic viability and ecological soundness according to a sustainability index formulated by Theodore (2001), and then analyzed using descriptive statistics and F tests to compare the different demographic characteristics of farmers, cultural practices and cropping systems.

Economic viability was measured using the following seven indicators:

1. Production efficiency. The non-weighted average of the yield for each activity on a farm expressed as a percentage of the average yield of that activity in the region.
2. Net return -The non-weighted average of the rate of return (net return divided by variable cost) of each activity on a farm,
3. Cultivated land utilization index- The total days land is occupied during the year, expressed as a percentage of full (365-day) utilization,
4. Technology use level- The non-weighted average score for the adoption of recommended practices for each activity 5. Farm family employment level- The total available farm family labor days spent for working on the farm
6. Self-reliant level-A score that measures the degree to which farmers were self-reliant with respect to farm machinery, farmyard manure, family labor
7. Self-sufficiency level-A score that measures the degree to which the farm household was self-sufficient in food (rice, pulses), fodder and fire woods.

Ecological soundness was the average of the two ecological soundness scores.

1. Eco-friendly technology use level: The non-weighted average scores for the adoption of eco-friendly activities for each activity, the technologies included suitable variety, and application of organic manure.

2. Organic recycling level: The non-weighted average (for all recycled products on the farm) of the proportion of the total product produced that is recycled.

The sustainability index was constructed by considering both sets of following indicators:

1. Economic viability: The average of the seven economic viability scores
2. Ecological soundness: The average of the two ecological soundness scores.

III. Results and Discussion

3.1. Demographic characteristic of farmers

The heads of households were between the ages of 20 and 78 with an average age of 49 years. Majority of the farmers were male. This suggests that farming is still customarily dominated by males in the study area. The family size was between the number of 3 and 12 with an average number of 6. Average size of cultivated land holdings was found around 1.73 hectare between lowest limit 0.06 hectare and upper limit 8.01 hectare. The educational levels of the majority of farmers were primary (39.47%), secondary (36.84%) and monastery educational level (19.3%) (Table 3.1).

Table 3.1. Demographic characteristic of farmers

Characteristics	Mean	Minimum	Maximum
Age (years)	49 ± 1.14	20.00	78.00
Family size (no.)	6 ± 0.19	3.00	12.00
Farm size(ha)	1.73 ± 0.37	0.06	8.01
Family labor (no.)	2 ± 0.12	1	4
Educational level (%)			
Monastary	19.30		
Primary	39.47		
Secondary	36.84		
High school	3.51		
Graduate	0.88		

3.2. Wetland based cropping systems

Three multiple cropping systems,sesame – rice – legume system, double rice cropping system and rice – legume were commonly grown in Yamethin Township. Rice was mostly grown for local consumption.There are three seasons for crop cultivation: pre-monsoon, monsoon and post monsoon. Cropping pattern was varied of changes of environmental factors.

In double rice cropping system, especially under irrigation, farmers grew summer rice immediately after monsoon rice. In rice – legumes systems, farmers grew only chickpea or green gram after monsoon rice. However, some non- irrigated areas and dry areas were left fallow during the summer season (Table 3.2).

3.3. Common cropping pattern of dryland crops

Three common legume- based cropping systems were observed in dryland system. In sesame + pigeon pea cropping pattern, sesame and pigeon pea were broadcasted together after the first shower in April. Early sesame could be harvested during the vegetative stage of pigeon pea. In legume based mixed cropping with cotton + pigeon pea or green gram and cotton were grown in alternate row (Table 3.3).

It was found that legume crops were the basic for double cropping for both wet and dryland cropping systems. The average areas of cultivated legume crops in cropping systems were considered to assess the ecological sustainability of cropping systems in most studies.

Table 3.2. Common cropping pattern of wetland crops

Cropping pattern	Months												Precent
	J	F	M	A	M	J	J	A	S	O	N	D	
Pattem 1	Rice (summer)						Rice (rainy)						44
Pattem 2	Legume (Chickpea, sunflower, green gram)			Sesame			Rice (rainy)					Legume (Chickpea, sunflower, green gram)	37
Pattem 3	Legume (Chickpea, sunflower, green gram)						Rice (rainy)					Legume (Chickpea, sunflower, green gram)	20

Table 3.3. Common cropping pattern of dryland crops

Cropping pattern	Months												%
	J	F	M	A	M	J	J	A	S	O	N	D	
Pattern 1	Sesame+ Pigeon pea												35
Pattern 2	Cotton + Pigeon pea												33
Pattern 3	Cotton + greengram												32

3.4. Seven indicators for measuring economic viability of different cropping system

3.4.1. Production efficiency

Production efficiency was measured by dividing the average yield for each practice on a farm with the average yield of that practice in the study area and express as percentage. Wetland + dryland (85.6) and wetland + dryland+ garden (80.6) systems were found to be high production efficiency than other three systems (Table 3.4).

3.4.2. Rate of net return of farmers

Profitability was analyzed based on financial returns in order to understand the performance of the systems. To obtain the average of the rate of return, net return was divided by variable cost of each practice on a farm. The average value of rate of net return in wetland + dryland system was found to be the highest (153.53). The average of rate of net return in wetland + garden was the lowest (23.57) (Table 3.4).

3.4.3. Cultivated land utilization index

Cultivated land utilization index was calculated with the total days of land occupied by cropping during the year, expressed as a percentage of full (365-days) utilization. The maximum mean value of cultivated land utilization index among five cropping systems was found in Garden only (96.49%) followed by wetland + garden (70.42%). The minimum mean value of cultivated land utilization index was found in wetland + dryland (45.37%) system (Table 3.4).

3.4.4. Technology use level of farmers

Technology use level was calculated with the average score for the adoption of recommended practices for each cropping activity. Time of irrigation, plant spacing, application of pesticides and insecticides, time of planting, hand weeding were used as indicators for scoring of wetland crops. Adoption of a practice was given 20 points of score. For all recommended practices the maximum score was 100.

For dryland crops, broadcasting or direct seeding, application of insecticides or pesticides, time of planting and hand weeding were used as indicators for scoring. Scoring point was 25 for adoption of each practice.

In garden crops, time of irrigation (two times per week in dry season) and application of fungicides were indicators for technology use level. If farmers follow all of two practices, the score was 100. If farmers used only one practice, the score was 50. The maximum average value of technology use level among five cropping systems was found in wetland + dryland (75) system followed by wetland + garden (70), wetland + dryland + garden (55), garden only (50) system. The minimum average value of technology use level among five cropping system was found in dryland + garden (30) (Table 3.4).

3.4.5. Farm family employment level of farmers

Farm family employment level was recorded with the average total available farm family labor days spent for working on the farm. The highest family employment level was found in dry land + garden (51.83) and garden only system (49.8) followed by wetland + dryland + garden (40.31) and wetland + garden (32.56) (Table 3.4). Most of farmers in the study area established garden within the boundaries of their house. Therefore, they could give more management to their garden crops. Most of the garden growing farmers could do vine pruning, hand weeding and picking of fruits with more number of farm family labour. In wetland and dryland, farmers had to use more hired labour due to the hardworking nature of farming and larger farm size. Therefore, farm family employment level was relatively low in wetland + dryland system.

Table 3.4. Seven indicators for economic viability of different cropping system

Indicators	Cropping systems					F value
	Garden only	wetland + garden	dryland + garden	wetland + dryland	wetland + dryland + garden	
1. Production efficiency	63.6	70.3	56.7	85.6	80.6	3.26*
2. Rate of net return	107.3	23.57	58.2	153.5	131.9	4.32**
3. Cultivated land utilization index %	95.96	70.62	66.94	46.43	61.92	6.5**
4. Technology use level	50	70	30	75	55	1.78ns
5. Family employment level	49.8	32.56	51.83	20.23	40.31	1.9**
6. Self-reliant level	47.08	46.42	36.11	41.34	58.12	5.18*
7. Self sufficiency level	13.35	90.95	8.33	79.81	92.75	13.21**
Economic viability (Average of seven indicators)	54.29	57.78	44.02	71.70	74.37	7.6**

* significant at 0.05 level, ** significant at 0.01 level, ns =non significant

3.4.6. Self sufficiency level of farmers

Self sufficiency was one of the indicators of economic viability. Sustainable agriculture should seek to minimize the dependency on external inputs (Alitieri, 2000). Input self sufficiency is determined on the basis of the ratio of local inputs cost. The higher the ratio the higher is the input self-sufficiency. The high dependency on external inputs increases farmers' vulnerability to reduce profit.

Self sufficiency level was determined by giving a score that measures the degree to which the farm household was self-sufficient in food (rice and pulses), fodder and fire woods. The scores of each food, fodder and fire woods were sufficient = 100, 2/3 sufficient= 75, half needed to buy = 50 and one forth needed to buy = 25 and not sufficient = 0. The highest self sufficiency level was found in wetland + dryland + garden (92.75) and wetland + garden (90.95) followed by wetland + dryland (79.81). The lowest self sufficiency among five cropping systems was found in dryland+ garden (18.33) and garden (13.35) only (Table 3.4).

3.4.7. Self reliant level of farmers

Self reliant level was a score that measured the degree to which farmers were self-reliant with respect to farm machinery(well, thresher, tractor,water pumping machine), farmyard manure (cowdung) and available farm family labor. The maximum self reliant level of farmers was found in wetland + dryland + garden system (58.13) followed by garden only system (47.08), wetland + garden (46.43). The minimum self reliant level of farmers among five cropping systems was found in dryland + garden (36.11) (Table 3.4).

3.5. Economic viability of different cropping systems

The economic viability was significantly different in five cropping systems. The average value of production efficiency, cultivated land utilization index and family employment level of garden only system was higher than the remaining systems. The values of self sufficiency level, technology use level and self reliant level in garden only systems were lower than other cropping systems. Therefore, the economic viability of garden only system (54.29) and dryland + garden (44.02) system were less than those of wetland + dryland + garden (74.37) and wetland + dryland (71.70) (Table 3.4).

3.6. Two indicators for measuring ecological soundness

3.6.1. Eco- friendly technology use level of farmers

This indicator was average score for the adoption of eco-friendly technologies for each activity. The technologies included in this consideration were suitable variety and application of organic manure.The score was given based on proporation of farm areas used with recommended suitable variety and application of organic manure. The score values were 100 for technology used on all farm areas, 75 for ¾, 50 for ½ and 25 for ¼ respectively. The maximum eco- friendly technology use level was found in wetland + dryland (100) followed by wetland + garden (75) and wetland + dryland + garden(75) (Table 3.5).

3.6.2. Organic recycling level of farmers

Organic recycling level was determined for all recycled products on the farm. It was an average score of the proportion of the total product produced that was recycled. The scores were given as recycled all products = 100, three fourth of the products = 75, half = 50, one fourth of the products = 25. The highest organic recycling level of farmers among five cropping systems was found in wetland + garden (85) and wetland + dryland (80) and wetland + dryland + garden (75) (Table 3.5).

3.7. Ecological soundness for five cropping systems

Ecological soundness was the average of eco-friendly technology use level and organic recycling level. The ecological soundness was significantly different in diversified cropping systems.With respect to ecological soundness, the system-wise analysis revealed that the ecological soundness of the 'wetland + garden' (77.5) and 'wetland + dryland'(75.2) systems were the highest with the similar level, followed by 'wetland + dryland + garden' (61.2) system. The 'garden only'(17.04) system was found to have the lowest ecological soundness level. Therefore, it can be generally assumed that the cultural practices of garden system in the study area have somewhat adverse impacts on the environment (Table 3.5).

Table 3.5. Ecological soundness for five cropping systems

Indicators	Cropping systems					F value
	Garden only	wetland + garden	dryland + garden	wetland + dryland	wetland + dryland + garden	
1. Eco-friendly technology use level	22.08	70.41	25.34	70.4	47.4	12.76**
2. Organic recycling level	12.00	85.00	65.00	80.0	75.0	6.59*
Ecological soundness (Average of two indicators)	17.04	77.75	45.17	75.2	61.2	2.31**

*significant at 0.05 level, , ** significant at 0.01 level

3.8. Sustainability index of five cropping systems

Sustainability index was calculated with the average of economic viability and ecological soundness. Sustainability level of five cropping systems was siginficantly different.The sustainability index was higher in wetland + dryland(73.4), wetland + dryland + garden(67.78) and wetland + garden (67.57) because these three cropping systems were higher in economic viability and ecological soundness than remaining systems (Table 3.6).

It is evident that the sustainability levels of three farming systems (wetland + dryland, wetland + dryland+garden and wetland + garden) were higher than those of the two other systems (garden only and dryland + garden).

Table 3.6. Sustainability Index of five cropping systems

Indicators	Cropping systems					F value
	Garden only	wetland + garden	dryland + garden	wetland + dryland	wetland + dryland + garden	
Economic viability	54.29	57.38	44.02	71.7	74.37	7.6**
Ecological soundness	17.04	77.75	45.17	75.2	61.2	2.11**
Sustainability index (Average of two indicators)	35.66	67.57	44.59	73.4	67.78	1.36**

** significant at 0.01 level

VI. Conclusion

Due to the biological nature of the study area, diversified farms were observed as garden only, garden + wetland, garden +dryland, garden + wet+ dryland and dryland + wetland. Legume based double cropping were also common in both dryland and wetland farming. Even in garden – legume crop was grown. Cultivation of legumes was one of the indicators for soil fertility management in assessing ecological soundness of cropping system. For further research, it is recommended to include this kind of criterion to assess sustainability. Due to high production efficiency, rate of net return and self sufficiency level, the diversified farms including the activities of rice based cropping were economically more viable. In assessing the ecological soundness of five diversified farms, wetland based farming systems were more ecological soundness due to high eco – friendly technology use level and organic recycling level. Low ecological soundness was found in garden only system. It can be generally assumed that the cultural practices of garden only system in the study area had somewhat adverse impacts on the environment. Agricultural Extension agents need to promote their activities in order to improve ecological soundness of garden only system. Therefore, diversified farm combined with wetland based cropping system showed higher economic viability, ecological soundness and sustainability. It is necessary for the research system to explore other possible options for locally appropriate strategies of assessing sustainability diversification. There should be further research for in depth study to determine sustainability of diversified farms in Myanmar.

V. References

Altieri, M. (ed.). 1987. Agroecology: The Scientific Basis of Alternative Agriculture. Westview, Boulder.

Angelsen, A., & Kaimowitz, D. (Eds.). 2001. Agricultural technologies and tropical deforestation. New York: CABI/CIFOR.

Ellis, F. 1998. 'Survey article: Household strategies and rural livelihood diversification'. The Journal of Development Studies. Vol.35, No.1, pp.1–38.

Roa, N. H and Rogers P.P 2006. Assessment of agricultural sustainability, vol.91, No.4, 25 August.

Theodore, R. K. January 2001. "Sustainability of diversified farms in Tambiraparani river command area, Southern India, AGREN No.108.

COLLECTION AND CONSERVATION OF PLANT GENETIC RESOURCES FROM DRY ZONE AREA OF MYANMAR

Min San Thein[1], Yi Yi Myint[2], Khin San Wai[3] and Khin Soe[4]

Abstract

Current status of plant genetic resources in Myanmar Seed Bank, and collection and conservation of crop genetic resources from dry zone area in Myanmar are presented in this paper. The Seed Bank was established in 1990 in cooperation between Myanmar Government and Japan International Cooperation Agency of Japanese Government. Five different activities are being performed by the staff personnel of the Seed Bank. Due to the collecting missions being unable to visit all areas in dry zone in Myanmar, all genotypes from farmers' hands could not be conserved in the Seed Bank, and the gap of the genetic diversities of dry zone crops conserved in Myanmar Seed Bank and in farmers' hands is large. Therefore, collection of important gene sources for dry zone crop improvement programs has been implemented in 46 townships in dry zone areas of Mandalay, Magway and Sagaing regions in Myanmar, and 1467 samples of 36 species were collected and conserved in the Seed Bank.

Key Words : Seed Bank, plant gentic resources, conserve, dry zone

Current status of plant genetic resources in Myanmar Seed Bank

Myanmar Seed Bank was established in 1990 in cooperation with JICA of Japanese government. It is located in the Campus of Department of Agricultural Research, Yezin, Nay Pyi Taw, Myanmar.

Mandates

Systematic conservation and sustainable utilization of PGR for food and agriculture in Myanmar

Goals

Goals at national level are food security and economic development of Myanmar by enhancing agricultural biodiversity through PGR conservation and their sustainable utilization.

1. *Assistant Research Officer, Myanmar Seed Bank, Department of Agricultural Research, P.O.Box 5820, Yezin, Nay Pyi Taw, Myanmar. E-mail: minsanthein@gmail.com*
2. *Research Officer and Head, Myanmar Seed Bank, Department of Agricultural Research, Yezin, Nay Pyi Taw, Myanmar*
3. *Director, Biotechnology, Plant Genetic Resources and Plant Protection Division, Department of Agricultural Research, Yezin, Nay Pyi Taw, Myanmar*
4. *Director General, Department of Agricultural Research, Yezin, Nay Pyi Taw, Myanmar*

Overall objective

To improve sustainable agriculture production and productivity through better use of PGR in Myanmar

Five activities

1. Exploration, collection, and introduction,
2. Characterization, regeneration, and multiplication,
3. Pre-breeding / Evaluation
4. Cold storage management, and
5. Documentation and data management

1. Exploration, collection, and introduction

Table 1. Collected samples (up to October 2010)

Sr. No	Crops	No. of collected samples
1	Rice	7608
2	Wild Rice	317
3	Cereal crops	2504
4	Food legume crops	2172
5	Oilseed crops	1710
6	Industrial crops	320
7	Horticultural crops	674
8	Others	20
	Total	**15325**

2. Characterization, regeneration, and multiplication

Characterization of germplasm is carried out according to the descriptors of IPGRI. Regeneration is conducted on the basis of monitoring germination tests, and shortage of seed amount of each accession in active collection is filled up by conducting multiplication.

3. Pre-breeding / Evaluation

Evaluation of germplasm for biotic and abiotic stress tolerance and some important traits is also being carried out in the Seed Bank.

4. Cold storage management

Table 2. List of conserved samples in Myanmar Seed Bank (up to January 2011)

Sr. No.	Crops	Number of accessions
1	Rice	6845
2	Wild rice	141
3	Black gram	126
4	Green gram	185
5	Cowpea	151
6	Chickpea	478
7	Pigeon pea	101
8	Soybean	80
9	Lima bean	66
10	Wild Vigna species	52
11	Maize	74
12	Wheat	1551
13	Sorghum	197
14	Millets	123
15	Groundnut	604
16	Sesame	36
17	Jute	42
	Total	**10852**

5. Documentation and data management

This unit keeps 3 types of data of germplasm; Passport data, characterization data, and stock data.

Distribution of germplasm

Plant genetic resources conserved in Myanmar Seed Bank have been distributed to abroad and domestic institutions for research and breeding programs.

Table 3. Distribution (up to October 2010)

Sr. No.	Crops	Number of accessions
1	Rice	11123
2	Wild rice	415
3	Cereal crops	221
4	Food legumes	220
5	Oilseed crops	10
6	Horticultural Crops	198
7	Industrial Crops	41
	Total	**14310**

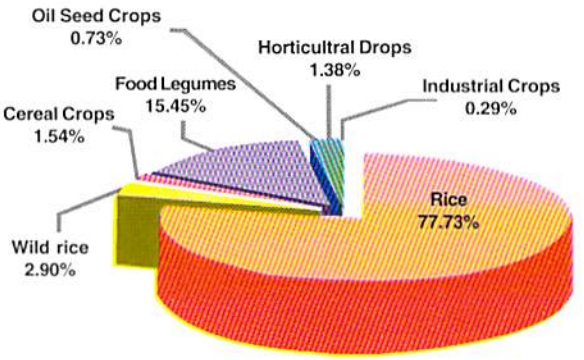


Figure 1. Distribution of PGR (up to October 2010)

Introduction

With the capacity of Myanmar Seed Bank being collaborated with Myanmar government and Japan International Cooperation Agency (JICA) of Japanese government, Myanmar is working to evaluate and conserve plant genetic resources as a national heritage (Tin Soe et al., 2003). During the Seed Bank-JICA project, some areas in Myanmar were explored for collecting multi-crop genetic resources and their wild relatives, and conserved in the Seed Bank. However, many areas have not been visited for collection of crop genetic resources. The genetic diversities for crop species in Myanmar Seed Bank are less than those in farmers' hands and the gap of the genetic diversities of dry zone crops conserved in Myanmar Seed Bank and in farmers' hands is still large. It is necessary to fulfill this gap to enrich the genetic resources of various crops in the Seed Bank. However, because of the collecting missions being unable to visit all areas in dry zone in Myanmar, all genotypes in farmers' hands could not be conserved in the Seed Bank. Number of accessions of dry zone crop genetic resources conserved in Myanmar Seed Bank is still limited. Nowadays, the application of adaptable crop varieties with drought tolerant genotypes for dry zone areas is increasingly needed in accordance with adverse environmental condition of climate change. Therefore, important gene sources for dry zone crops improvement programs are undoubtedly needed. Furthermore, landraces of dry zone crops should also be collected and conserved before losses occur. For these reasons, dry zone areas in Myanmar were explored for collecting crop genetic resources.

Objectives

1. To enlarge the genetic diversity of dry zone crop genetic resources in Myanmar Seed Bank
2. To improve conservation and sustainable utilization of dry zone crop genetic resources for food and agriculture

Method

1. Collection site

For collecting dry zone crop genetic resources, 18 townships in Mandalay region, 15 townships in Magway region and 13 townships in Sagaing region (Tables 1, 2, and 3) were explored from Seed Bank-JICA project (1997~2002) to October, 2010.

2. Collection source

Farm land, threshing floor, farm store, local market, purchasing center, and home-garden / backyard garden were visited for collecting the landraces of dry zone crops.

3. Collecting sample

Seed samples of multi-crop landraces from dry zone areas of Mandalay, Magway and Sagaing regions in Myanmar were collected along with passport data.

Result and Discussion

1. Samples collected from Mandalay Region

Four hundred and ninety three samples of crop landraces were collected from 18 townships in Mandalay region (Table 4). Among the collected samples, vegetable crop samples showed the highest frequency (29%), followed by industrial crops (28%), food legumes (19.1%), rice (9.1%), cereal crops (8.7%), and oilseed crops (6.1%).

Table 4. List of collected samples in dry zone area of Mandalay Region, Myanmar

Sr. No.	Township	Rice	Cereal crop	Oil seed crop	Vegetable	Industrial crop	Food legume	Total	Percent (%)
1	Mandalay	5	2		1	2	26	36	7.3
2	Kyaukse	1	4		10		5	20	4.1
3	Nyaung U	3	6	25	16		37	87	17.6
4	Kyaukpataung	6	3		31		2	42	8.5
5	Tatkone	1			6			7	1.4
6	Yamethin	19	1		24		1	45	9.1
7	Pyawbwe				6		1	7	1.4
8	Meikhtila	3	7	1	1			12	2.4
9	Wantwin				4			4	0.8
10	Tharsi	1	9	1	7			18	3.7
11	Mahlaing				12	135		147	29.8
12	Myingyan	1	5	3	17		10	36	7.3
13	Ngwarhtokyi	5	2		5			12	2.4
14	Tada U				2			2	0.4
15	Amarapura						10	10	2.0
16	Sintku					1		1	0.2
17	Taungthar		4		1			5	1.0
18	Sintkaing						2	2	0.4
	Total	**45**	**43**	**30**	**143**	**138**	**94**	**493**	
	Frequency (%)	9.1	8.7	6.1	29.0	28.0	19.1		100.0

2. Samples collected from Magway Region

Four hundred and sixty four samples of crop landraces were collected from 15 townships in Magway region (Table 5). Among the collected samples, cereal crops showed the highest frequency (29.7%), followed by food legumes (26.7%), vegetable crop samples (18.8%), oil seed crop (15.3%), industrial crops (5.4%), and rice (4.1%).

Table 5. List of collected samples in dry zone area of Magway Region, Myanmar

Sr. No.	Township	Rice	Cereal crop	Oil seed crop	Vegetable	Industrial crop	Food legume	Total	Percent (%)
1	Yesagyo		3				9	12	2.6
2	Myaing	3	8				12	23	5.0
3	Magway		3	2	2	10	33	50	10.8
4	Minbu		2		16	1	1	20	4.3
5	Salin	1	39	11	10	7	13	81	17.5
6	Saku	1						1	0.2
7	Pwintphyu	1	4	2	23	1	16	47	10.1
8	Seikphyu	1	11				5	17	3.7
9	Pakokku		11	14			17	42	9.1
10	Pauk	5	13				5	23	5.0
11	Yenanchaung		1		5	1	3	10	2.2
12	Chauk				19			19	4.1
13	Aunglan				4			4	0.9
14	Taungdwinkyi	2	5	13	4	1	3	28	6.0
15	Natmauk	5	38	29	4	4	7	87	18.8
	Total	**19**	**138**	**71**	**87**	**25**	**124**	**464**	
	Frequency (%)	4.1	29.7	15.3	18.8	5.4	26.7		100.0

3. Samples collected from Sagaing Region

Five hundred and ten samples of crop landraces were collected from 13 townships in Sagaing region (Table 6). Among the collected samples, food legume samples showed the highest frequency (40.2%), followed by cereal crops (29%), vegetable (22.7%), rice (5.7%), and oilseed crops (2.4%). None of the industrial crop sample was collected from this region.

Table 6. List of collected samples in dry zone area of Sagaing Region, Myanmar

Sr. No.	Township	Rice	Cereal crop	Oil seed crop	Vegetable	Industrial crop	Food legume	Total	Percent (%)
1	Monywa		45	2	27		125	199	39.0
2	Sagaing		4		4			8	1.6
3	Myinmu		1		15		4	20	3.9
4	Chaung U	2	4	4	5		28	43	8.4
5	Myaung		2		3		13	18	3.5
6	Yinmabin	11	2					13	2.5
7	Shwebo	8	0		5		12	25	4.9
8	Pale		3	3	9		4	19	3.7
9	Khin U	1			13			14	2.7
10	Wetlet	4			12			16	3.1
11	Dapeyin				13			13	2.5
12	Kantbalu		3	2			3	8	1.6
13	Ye Oo	3	84	1	10		16	114	22.4
	Total	**29**	**148**	**12**	**116**		**205**	**510**	
	Percent (%)	5.7	29.0	2.4	22.7		40.2		100.0

4. Total collected samples

During the exploration and collection missions, 1467 samples of 36 crop species were collected from dry zone areas in 3 regions in Myanmar (Table 7). Collected samples of crops, then, were categorized into six groups. Based on their utilization, crop species were grouped into two, such as cultivated and wild rice. Four crop species - wheat, maize, sorghum and millet for cereal crops; 3 crop species - groundnut, sesame and sunflower for oilseed; 11 crop species - bottle gourd, bitter gourd, ridge gourd, sponge gourd, snake gourd, pumpkin, watermelon, cucumber, tomato, chilly and ice potato for vegetable; 4 crop species - cotton, Jatropha, caster and elephant' s yam for industrial and 12 crop species - green gram, black gram, cowpea, pigeon pea, chickpea, lima bean, garden pea, rice bean, horse gram, kidney bean, soybean and wild Vigna for legume crop.

Table 7. Crop samples collected from 3 regions of dry zone areas in Myanmar

Sr. No.	Township	Rice	Cereal crop	Oil seed crop	Vegetable	Industrial crop	Food legume	Total	Percent (%)
1	Mandalay	45	43	30	143	138	94	493	33.6
2	Magway	19	138	71	87	25	124	464	31.6
3	Sagaing	29	148	12	116	-	205	510	34.8
	Total	**93**	**329**	**113**	**346**	**163**	**423**	**1467**	
	Percent (%)	6.3	22.4	7.7	23.6	11.1	28.8		100

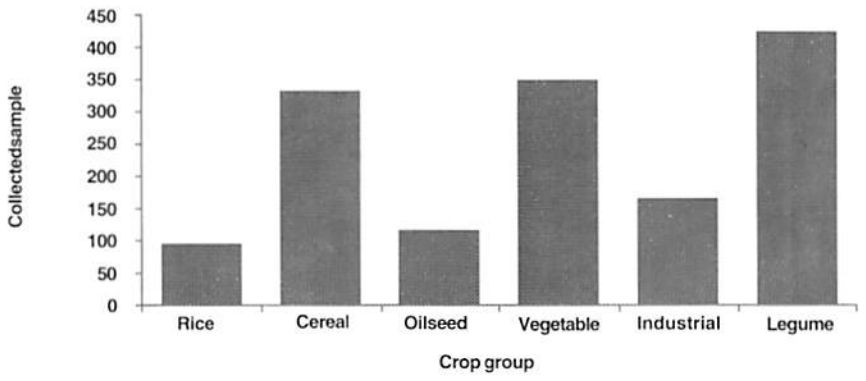


Figure 2. Samplex collected from dry zone area s in Myanmar

Summary

Role of PGR: Plant genetic resources are the essential basic raw materials for crop improvement.

Opportunity: Seed Bank is the only genebank in Myanmarfor conserving plant genetic resources, those are national heritages.

Strength: Reducing breeders' work loads after the establishment of the Seed Bank and distributing more research and breeding materials.

Threat: Local varieties in dry zone areas are replaced by improved cultivars at a rapid pace.

Needs: Cooperation of international, regional and local institutions is needed.
Constraint: Exploration is expensive.

Future plan: Up to October, 2010, 15325 samples of various crop species and their wild relatives were collected from all states and regions in Myanmar. For dry zone areas, the missions covered 46 townships in three regions and collected 1467 samples showing less than 10% of the samples collected from all states and regions in Myanmar suggesting the rest sites in dry zone areas should be conducted for further exploration and collection in the same three regions.

Acknowledgement

The authors thank to short-term and long-term Japanese experts and JICA of Japanese government for technical, financial and material support for the exploration and collection missions. We would like to thank Dr.Tin Htut, Director of Rice Division, Department of Agricultural Research, for valuable comment and suggestion on plant genetic resources aspect. Seed Bank staff are highly appreciated for their kind participation during the exploration trips and / or post trip handling of the collected samples. We also would like to thank farmers who supply seed samples and for being patient in interviewing for passport data, and extension staff of Myanma Agriculture Service in Mandalay, Magway and Sagaing regions for their assistance during the trips.

Reference

Tin Soe, John Ba Maw, Kyi Aung, Than Sein, Win Twat, Khin Aye, L-Nang Kha, Yi Yi Myint and Tin Htut. 2003. Current status and prospects of plant genetic resources conservation and utilization in Myanmar. Pp 4–18. In: Plant genetic resources conservation and use in Myanmar, A Garcia.

V Ramanatha Rao, P E Sajise, and U Tun Than (editors). Proceeding of the national workshop on conservation and utilization of plant genetic resources in Myanmar for sustainable agricultural development and food security, 1 October 2002, Myanma agriculture office headquarters, Myanmar.

CLIMATE CHANGE AND PREPAREDNESS AT THE VILLAGE LEVEL IN COASTAL AREAS OF BANGLADESH: A SITUATIONAL STUDY

Md. Ataur Rahman[1],Dr. A.K. Sharifullah[2] and Dr. Swapan Kr. Dasgupta[3]

Abstract

This sample survey revealed that coastal people have some awareness about gradual changes in climate. They understand that tidal water level has risen and inundated more and more land day by day. Number of cyclones has increased and comes with more speed than in the past. It does not rain in suitable times but rains in unsuitable times for agriculture. Involvement in agriculture has been reduced in coastal areas due to these changes in climate. People have some apprehension about possible future changes in climate. They think that due to land loss, water stagnation and salinity, their involvement in agriculture, fish culture, livestock and poultry rearing will be reducing and involvement in non-farm sectors will be increasing gradually. Therefore, coastal villagers opined that GOs and NGOs should patronize long barrage construction with adequate height and number of sluice gates; should increase number and size of cyclone centers. According to their opinions migration and livelihood change may be coping strategy for them. A large scale in depth research should be conducted by concerned GOs, NGOs and UN body taking samples representative of all coastal areas of Bangladesh before formulating short term, medium term and long term national policies, strategies, programs and projects for coping with past and future changes in climate in the coastal areas of Bangladesh.

Key Words : Climate change, coastal people, awereness, coping strategy

Introduction

It is often cited that very densely populated Bangladesh is the most vulnerable territory to frequent natural calamities and climate change due to its flat and low-lying topography; widespread poverty and dependence on climate sensitive sectors for livelihoods, particularly agriculture and fishery. Around ten percent of the territory is hardly one meter above the mean sea level and one third is under tidal excursions. The country has two contrasting environments to the north and the south. The Himalayas, Khasia and Jaintia hills are situated to the northern side and the Bay of Bengal to the south. All those influence climate and environment of the country highly.

1. Director General, Bangladesh Academy for Rural Development

2. Director, Administration, Bangladesh Academy for Rural Development

3. Director, Rural Administration and Local Government, Bangladesh Academy for Rural Development
Email: swpndsgpt687@gmail.com.

World Meteorological Organization (WMO) and United Nations Environment Program (UNEP) jointly established the Intergovernmental Panel on Climate Change (IPCC) to look after this global issue (Bangladesh Summery Report, 1994) in 1988 in response to growing national and international concerns regarding the threats due to climate change. There is now clear scientific evidence that the gradual increase in concentration of greenhouse gases in the atmosphere is causing global warming. Sea level rise is among the most profound impacts of climate change. Thermal expansion of ocean water and melting of Arctic-ice due to higher ambient temperatures would lead to a rise in the average sea level by about 50 cm by the end of current century (Warrick et al. 1996).

Coastal areas in Bangladesh are on the 'front line' of climate change, directly affected by storm surges, drainage congestion and sea level rise. At least 1.4 million hectare of the coastal and offshore areas of Bangladesh, inhabited by about 15% of the population is directly affected by the intrusion of saline water into the surface (Bangladesh Summery Report, 1994). Saline water from the Bay of Bengal already penetrates into 100 kilometers inland during the dry season, and climate change is likely to exacerbate this situation further.

If sea level rises up to one meter, due to inundation and stagnation of saline water, Bangladesh may lose up to 15 percent of its landmass and up to 30 million people could become climatic refugees. The livelihood of coastal people will be affected to a great extent if the sea level rises up to the predicted level in future. Lot of people will loose their habitation and productive agricultural land. All these issues are in the process of scientific assessment, academic discussion and coming as most critical global problems. Many countries are taking action to combat the situation.

The coastal area of Bangladesh represents an area of 47,211 sq. km which is 32 percent of the total geographical area of the country and where 35 million people of 6.85 million households live (Population census 2001). The high rate of population growth and scarcity of land push millions of people to live in the low lying and more hazardous coastal areas. Future sea level rise, in addition to changing flood scenarios may change the habitation pattern with significant population displacement from low-lying coastal and flood plains. Climate change will have direct influence on crop yield, predicted to be reduced crop yield due to increase in flooding intensity, submergence effect, salinity and variability in precipitation.

Several studies were conducted in Bangladesh to assess the change of climatic effect in different sectors. But what the people themselves in coastal areas of Bangladesh are thinking about the issue, what is the preparedness situation at the village level to face the apprehended problems and what will be their livelihood in hazardous situation are not yet known. Not much information is available about the preparedness of coastal people to cope with the situation. All those need to be assessed for equipping people on how to cope with changes in climate matching with people's demands.

General Objective

In the above background, the general objective of this study was to investigate coastal people's awareness about climate change, its effects and preparedness at the village level to cope in selected coastal areas of Bangladesh.

Specific Objectives

To achieve the general objective, the specific objectives of the study were as follows.

(1) To examine the awareness of coastal people about the issues of climate change.
(2) To assess the awareness of coastal people about possible impact of climate change on their livelihoods.
(3) To observe the extent of preparedness at the village level to cope with possible effects of climate change.

Methods

Four coastal villages were selected purposively from four unions of three sub-districts under two districts, Noakhali and Bhola. These study areas are historically prone to natural calamities like cyclone and high tidal insurgence of saline water. The cyclone in Bhola and Noakhali districts on November 12, 1970 was the deadliest tropical cyclone on record and is one of the deadliest natural disasters in recent history. The exact death toll will never be known, but it is estimated that between 300,000 and 500,000 people and millions of livestock and poultry lost their lives in one night due to very high tidal insurgence (Kabir, et.al, 2007). Such natural calamities are occurring in the study areas frequently (Table 1).

Table 1. Purposively selected study area

Districts	Sub-districts	Unions	Villages
Noakhali	Hatia	Char Iswar and Hiruni	Char Lotia and Purba Rasulpur
Bhola	Bhola Sadar and Doulatpur	Rajapur and Medua	Paschem Sultani and Medua

Land ownership is considered by Bangladesh Bureau of Statistics (BBS) as a basic factor for socio-economic categorization of rural people in Bangladesh. Therefore, 200 households proportionately representing all categories of landowners were selected as sample households for this study. An elderly person of each of the sample households was interviewed with the aid of a pre-structured questionnaire. Thus, data were collected from a total of 200 respondents. Respondents were selected proportionately from all landowner categories considering their total number in the rural community. Highest frequency of respondents was selected from small landowners because of their highest number in the rural community (Table 2).

Table 2. Distribution of sample respondents by land ownership

Land ownership categories (in acre)	Number of respondents	Number of respondents	Total respondents	%
Landless (0.00-0.49)	37	29	66	33
Small land owner (0.50-2.49)	45	45	90	45
Medium land owner (2.50-7.49)	13	22	35	18
Large land owner (7.50 and above)	05	04	09	5
Total	100	100	200	100

Source: Field Study, 2010

Findings

According to the information of Table 3, majority (66-67%) of the coastal people understand that tidal water level has increased by 2-3 feet approximately and inundates gradually more and more land. Number of cyclones has increased and comes with more speed than before the last 25 years. According to their understanding (66%), it does not rain in suitable times but rains in unsuitable times for agriculture; riverbank erosion has increased; and salinity in water and soil has increased in their area. All these information imply that coastal people have moderate awareness about changes occurred in the climate of their area.

Table 3. Coastal people's awareness about the changes in climate during the last 25 years

Coastal people's views	Hatia	Bhola	Total	% (n=200)
Tidal water level has increased by 2-3 feet approximately than before	61	73	134	67
Cyclones come with more speed than before	21	50	71	36
Number of cyclones has increased than before	58	76	134	67
Rains in unsuitable time for agriculture	19	25	44	22
Does not rain in suitable time for agriculture	68	65	133	66
Salinity in water has increased than before	02	36	38	19
Salinity in soil has increased than before	15	07	22	11
Depth of river / canal has decreased than before	08	18	26	13
River bank erosion has increased than before	43	72	115	58
Char area has increased than before	-	06	06	3

Source : Field Study, 2010

Coastal people have the apprehension that more changes will be occurring in the climate of their area during the next 25 years too similar to that during the last 25 years. A few of them have the opinion that permanent water logging will be occurring in more areas and some char areas will be eroded by river. Sixteen percent respondents possess the opinion that only God knows what will be happening in future. All these information substantiated that coastal people are able to apprehend the possible changes in climate during the next 25 years (Table 4).

Information of Table 5 indicates that as impact of climate change, coastal people's involvement in agriculture reduced during the last 25 years and it will be reducing more remarkably during the next 25 years. Involvement in fishing in natural water bodies remained almost same during the last 25 years but it will be reducing remarkably due to drastic reduction of ratio between amount of fish and number of fishermen in natural water bodies. Increasing trend was observed in case of their involvement in micro trade. Involvement in job increased during the last 25 years and it will be increasing further during the next 25 years because people will be changing their profession due to decrease of employment opportunities in farm, forestry and fishery sectors.

Table 4. Coastal people's awareness about possible changes in climate during next 25 years

Coastal people's views	Hatia	Bhola	Total	% (n=200)
Tidal water level will be increasing more than now	61	73	134	67
Speed of cyclones will be increasing more than now	21	50	71	36
Number of cyclones will be increasing more than now	58	76	134	67
Raining in unsuitable time for agriculture will be increasing more than now	19	25	44	22
Raining in suitable time will be decreasing more than now	68	65	133	66
Salinity in water will be increasing more than now	02	36	38	19
Salinity in soil will be increasing more than now	15	07	22	11
Depth of river / canal will be decreasing more than now	08	18	26	13
River bank erosion will be increasing more than now	43	72	115	58
Char area will be increasing more than now	-	06	06	3
Some chars will be eroding by river	01	11	12	6
Permanent water logging will be occurring in more areas than before	02	25	27	14
Only God knows what will be happening in future	22	09	31	16

Source : Field Study, 2010

Table 5. Coastal people's awareness about possible impact of climate change on livelihoods

Livelihoods	25 years back (n=200)			At present (n=200)			After 25 years (n=200)		
	Noakhali	Bhola	Total %	Noakhali	Bhola	Total %	Noakhali	Bhola	Total %
Agriculture	93	94	187 (94)	71	73	144 (72)	46	33	79 (40)
Fishing to sell	34	65	99 (50)	41	53	94 (47)	28	12	40 (20)
Fish trading	02	06	08 (4)	02	07	09 (4)	-	02	02 (1)
Labour	18	21	39 (20)	30	28	58 (29)	15	07	22 (11)
Job within country	01	03	04 (2)	10	14	24 (12)	25	34	59 (30)
Job in abroad	-	-	-	01	-	01 (0.5)	-	03	03 (1.5)
Skilled labour	02	02	04 (2)	05	05	10 (5)	03	-	03 (1.5)
Micro trade	07	12	19 (10)	16	19	35 (72)	25	26	51 (26)
Others	03	04	07 (4)	15	137	152 (76)	73	91	164 (82)

Source : Field Study, 2010

The highest ratio of (46%) coastal people considered that migration to other areas of the country may be a coping strategy with the effects of climate change. People may migrate and search work in other areas of the country. This implies that coastal people's opinions on the ways of coping with climate change are biased to migration to other areas in the country and to change their traditional livelihood pattern. Such intensions are contributing a lot to the increase of slum areas in Bangladesh (Table 6).

Table 6. Coastal people's awareness on coping with possible effects of climate change

Coastal people's views on the ways of coping	Noakhali	Bhola	Total	% (n=200)
Searching work in other areas within country	43	34	77	39
Engagement in non-farm activities due to decrease of arable land	34	37	71	36
Receiving govt. services and supports	44	29	73	37
Educating children to get job	26	31	57	29
Working in abroad	02	04	06	3
Migration to other areas of the country	41	50	91	46
Involvement in other works leaving fishing due to lack of natural fishes	03	08	11	5.5

Source : Field Study, 2010

About the probable effects of tidal inundation and stagnation of saline water in more agricultural and forest lands in the next 25 years the coastal villagers opined that agriculture will be decreasing due to wet land; fish culture will be decreasing due to salinity in water; stagnant water removal will become difficult; diarrhea, dysentery and many other diseases will break out in the people as epidemics; livestock and poultry rearing will be decreasing due decrease of pasture land; and drinking water crisis will be increasing more. All these information implies that coastal people's dueling, livelihood and lives will become more miserable gradually during the next 25 years (Table 7).

Table 7. Coastal people's views on probable effects of tidal inundation / stagnation of saline water in more agricultural and forest land in the next 25 years

Coastal people's views	Noakhali	Bhola	Total	% (n=200)
Food:				
Food deficit will be occurring	28	33	61	31
Food insecurity will be increasing	44	46	90	45
Allah will be giving us food	10	09	19	10
Did not think about food of future	46	46	92	46
Fuel:				
Did not think about fuel of future	52	50	102	51
Fuel deficit will be occurring	24	49	73	37
Fuel crisis will be increasing	36	46	82	41
Agriculture:				
Agriculture will be decreasing due to wet land	100	100	200	100
Salinity in soil will be increasing	46	34	80	40
Poultry, Fishery and Livestock:				
Fodder crisis of livestock and poultry will be occurring	49	40	89	45
Diseases of livestock and poultry will breakout as epidemics	20	70	90	45
Livestock and poultry rearing will be decreasing	72	66	138	69
Fish cultivation will be decreasing	98	100	198	99
Transport Communication:				
Road transport and communication will be breaking down	46	78	124	62
Water communication and transport will be increasing	21	29	50	25
Risk in transport and communication will be increasing	75	74	149	75
Education:				
Educational institutions will become unable of operation	56	97	153	77
Do not know how to continue children's education	29	18	47	24
Children's education will be stopping	48	73	121	61
Public Health:				
Drinking water crisis will be increasing	72	67	139	70
Diarrhea will breakout due to impure water drinking	30	27	57	29
People's toilet will be becoming unusable	99	97	196	98
Dysentery and other disease will breakout in the people as epedimics	79	96	175	88
Others:				
Stagnant water removal will become difficult	100	100	200	100
Social cooperation will break down	93	64	157	79

Source : Field Study, 2010

Coastal people's suggestions for coping with apprehended problems and effects of tidal inundation and stagnation of saline water in more agricultural and forest-land in the next 50 years are as follows. GOs and NGOs should patronize installation of pure drinking water sources; establishment of hospitals; construction of long barrage with adequate height and adequate number of sluice gates; use of cement blocks for resisting river erosion; and increase in number and size of cyclone centers (Table 8).

Table 8. Coastal people's suggestions for coping with probable problems / effects of tidal inundation / stagnation of saline water in more and more agricultural and forest land in next 25 years

Coastal people's suggestions regarding coping	Noakhali	Bhola	Total	% (n=200)
Economic:				
GOs and NGOs should patronize non-farm employment opportunities for people to buy food and fuel	30	29	59	30
Duck rearing by people should be patronized	03	100	103	52
GOs and NGOs should patronize professional skill development training to people more	15	15	30	15
GOs and NGOs should patronize coastal area friendly industrialization	23	09	32	16
Public Health:				
GOs and NGOs should patronize installation of pure drinking water sources	94	89	183	92
GOs and NGOs should patronize establishment of hospitals in the affected locality	86	96	182	91
Infrastructure:				
GOs and NGOs should patronize construction of long barrage with adequate heights and sluice gates	88	94	182	91
GOs and NGOs should patronize use of cement blocks for resisting river erosion.	77	97	174	87
Canals of limited use to people should be closed by government at their ends	33	28	61	31
High land may be created to be used by people in various purposes	8	40	48	24
GOs and NGOs should increase number and size of cyclone shelter centers	71	96	167	84
Social:				
Children should migrate in other areas of Bangladesh for education	45	49	94	47

Conclusion

Coastal people are moderately aware about the changes in the climate during the last 25 years. Majority of them understand that tidal water level has increased gradually which inundates more and more land day by day. Number of cyclones has increased and comes with more velocity than in the past. It does not rain in proper times but rains in improper times. Riverbank erosion has increased. Salinity in water and soil has increased. Involvement in agriculture has reduced. Involvement in fishing in natural water bodies has remained almost same. Involvement in job has increased.

Coastal people can apprehend the possible changes in climate in the next 25 years. They understand that their involvement in agriculture will reduce more remarkably due to land loss and salinity. Fishing in natural water bodies will reduce more remarkably due to drastic reduction of fish in natural water bodies. Involvement in job in non-farm sector will increase further in future. People will change their profession due to decrease of employment opportunities in farm, forestry and fishery sectors.

According to coastal people's views on probable effects of tidal inundation and stagnation of saline water in more and more agricultural and forest lands in the next 50 years agriculture will stop due to wet land; fish culture will stop due to salinity in water; stagnant water removal will be difficult; diarrhea, dysentery and many other diseases will break out in the people; livestock and poultry rearing will stop due decrease of pasture land; and drinking water crisis will aggravate.

For coping with apprehended problems and effects of tidal inundation and stagnation of saline water in more agricultural, homestead and forestland in the next 25 years, the coastal people suggested that GOs and NGOs should patronize installation of pure drinking water sources; establish hospitals; construct long barrage with adequate height and adequate number of sluice gates; patronize use of cement blocks for resisting river-erosion; and increase number and size of cyclone centers. Highest ratio of coastal people considers that migration to other areas of the country may be a coping strategy with the climate change and they are biased to change their traditional livelihood pattern.

A large scale in depth study should be conducted taking samples from all socio-economic classes of people represented by all coastal areas of Bangladesh before formulating short term, medium term and long term national policies, strategies and actions for coping with the climate change and its impacts.

References

Government of Bangladesh and Government of The Netherlands 1994. Vulnerability of Bangladesh to Climate Change and Sea Level Rise - Summary Report : Concepts and Tools for Calculating Risk in Integrated Coastal Zone Management. Ministry of Environment and Forest of Bangladesh Government and Ministry of Foreign Affairs of Netherlands Government. Dhaka, Bangladesh. 39 pp.

Kabir, M.M.; Saha, B.C.; Hye, J.M.A. "Cyclonic Storm Surge Modeling for Design of Coastal Polder" (http://web.archive.org/web/20070622000638/http:www.mbd.org/html/PUBS/publications/P024.PDF) (PDF). Institute of Water Modeling. Archieved from the original (http://www.iwmbd.org/html/PUBS/publications/P024.PDF) on 2007-06-22.http://web.archive.org/web/20070622000638/http://www.iwmbd.org/html/PUBS/publications/P024.PDF.

Warrick, R. A., C. Le Provost, M. F. Meier, J. Oerlemans and P. L. Woodworth (1996). 'Changes in Sea Level', in J. T. Houghton, L. G. Meoro Filho, B. A. Callander, N. Harris, A. Kattenberg and K. Maskell, eds., Climate Change . 1995. The Science of Climate Change – Contribution of Working Group 1 to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press, pp. 359-405.

ENVIRONMENTAL IMAGES OF RURAL PEOPLE IN THE DRY ZONE, MYANMAR: CASE STUDY ON POPA VILLAGE, KYAUKPADAUNG TOWNSHIP

Dr Saw Pyone Naing[1]

Abstract

Popa is a typical place in the Dry Zone of Myanmar. It is important place for forest, streams, springs and wildlife of the Dry Zone. Environmental image of villagers in Popa area is mainly related to these physical features and wildlife park. Strong images of villagers in Popa include neighbouring houses, mountain and village roads. Composite images of the villagers covered residential area, transport facilities, religious sites and physical features surrounding Popa Mountain. These results can be helpful for the environmental planning and the rural assessment related to environmental affairs.

Key Words : Composite Images, Dry Zone, Environmental Images, Mental Map, Popa Mountain, Rural Assessment

Introduction

Mental images are the basis of human behavior. They are personal representations based on observations and past experiences. Each individual has a personal image of the world, and each shares all or part of that image with members of a social group. This image tends to be centered on the individual or the group.

An image may be nothing more than an inventory of the element; however, if decisions are to be made, a quality of appraisal must be added, a finding that something is beneficial or harmful, beautiful or ugly, desirable or undesirable.

Objectives

Main objectives of this study are

- to assess villagers' knowledge and capabilities on environment through their capacity map, quantify and qualify, and
- to contribute local peoples' attitudes for the rural assessment in the Dry Zone of Myanmar by using mental maps and images.

Methodology

All 39 households of Popa Village were selected to survey by applying questionnaire distribution and semi-structured interviews with villagers of Popa Village to get mental maps of the villagers. Mental maps are usually applied in rural appraisal by doing participatory mapping and modeling which include social map, health map, well-being map, resource map, mobility map etc.

1. *Professor Pro-Rector, University of Mandalay, Ministry of Education*

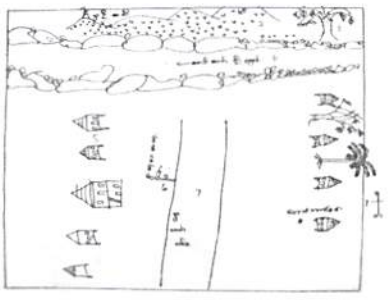


Figure 1. A sample of mental map drawn by the villager of Popa Village

A sample of mental map drawn by the villager of Popa Village is shown in Figure 1. Questionnaire distribution and intensive interviews were also done by the research team (Figure 2). From each household, one of the family members was requested to answer the questions and depict a mental map.

Figure 2. Questionnaire distribution and interview with villagers of Popa Village study area

Study area, Popa Village, is located at 50 miles northeast of Yenangyaung, 30 miles southeast of Bagan and 9 miles away from Kyaukpadaung Town. Popa Village is lying at the foothill of Popa Mountain which is landmark in the hearth of the Dry Zone. The range of Mount Popa is about 9 miles long and 8 miles wide and covers about 70 square miles. In fact, this study area is very unique and composed of a different physical setting from the surrounding areas of the Dry Zone. (Figure 3 and 4)

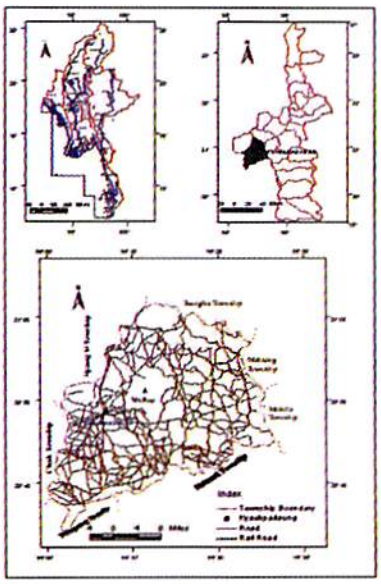


Figure 3. Location of Popa Village

Figure 4. Physical feature of Popa Mountain

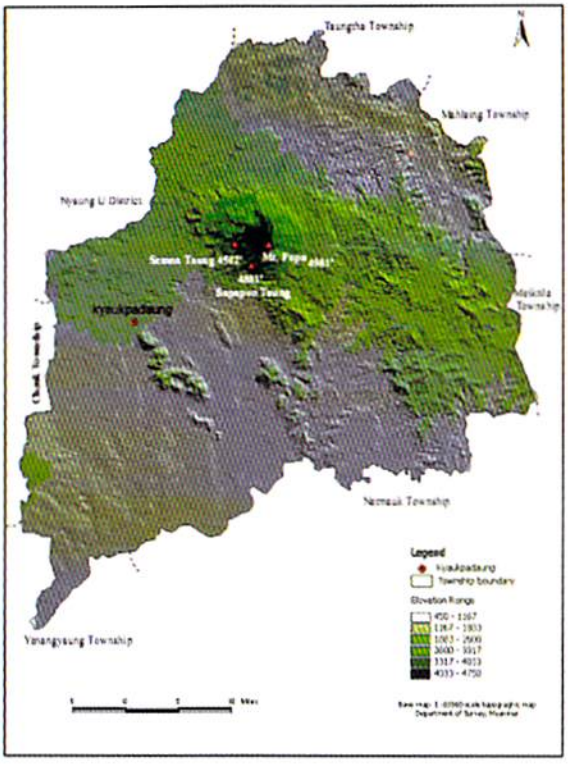


Figure 5. Physical feature of Popa Mountain

The study area lies in the foot hill of isolated mountain surrounded by plain areas of the Dry Zone. The area is covered with forest and trees. (Figure 5)

Results

General profile of respondents

All the respondents in the survey are above 20 years of age. Therefore, these respondents are matured and persons with knowledge about their environment. Among 39 persons, 24 persons are females and 15 persons are males. Therefore, there is no gender bias in the survey. (Table 1 and 2)

Table 1. Age group of responded villagers

Age Group	Number
<20	0
21-40	17
41-60	11
>60	11

Table 2. Gender distribution of responded villagers

Gender	Number
Male	15
Female	24

Most of the villagers, 19 persons out of 39 persons, are cultivators such as farmers and gardeners. The second largest amount, 15 persons, have own businesses and 12 persons are government staff. (Table 3) Therefore, most of them can notify their environment very well.

Table 3. Type of job among responded villagers

Type of Job	Number
Own business	15
Farmer	12
Government staff	11
Gardener	7
Shopkeeper	3
Other	1

Most of the responded villagers are in monastic, primary and middle school level of education. There are 3 persons out of 39 persons, in university level of education. There are 5 persons who have no education. But, they can read and write for the basic requirements such as their names, address etc. (Table 4) Therefore, education level of villagers did not hinder the knowledge of villagers about their environment.

Table 4. Education level of responded villagers

Education Level	Number
Monastic	9
Middle school	8
Primary school	7
High school	7
University	3
No education	5

Images on environment

According to the questionnaire results, the images of villagers focused on the changes in Rain, Temperature, Flora, Fauna, Agriculture, Life style, and General environmental conditions. These images are closely related to the intimate physical features.

According to the images of the villagers there are changes in rain and main reasons for changes in rainfall amount are climate change, deforestation and drought. (Table 5)

Table 5. Images on changes in rain

Perception	Number (%)
Climate change	11
Deforestation	4
Drought itself	3
Others	3
Plantation of Eucalyptus	1

The main reasons defined by villagers for the changes in temperature are deforestation and climate change. Therefore, the villagers want to conserve trees and forest in natural condition for maintaining rain and temperature. (Table 6)

Table 6. Images on changes in temperature

Perception	Number (%)
Deforestation	7
Climate change	6
Drought	3
Plantation of Eucalyptus	2
Others	2

According to villagers of Popa Village, there are changes in fauna and flora in Popa area. The main reasons defined by villagers for the changes in fauna are the growth of residential area and the founding of National Park. The growth of residential area drive the animals to remote areas whereas the founding of National Park keeps the animal to live in Mount Popa Area.

Table 7. Images on changes in fauna

Perception	Number (%)
Residential growth	10
National Park	4
Deforestation	1
Water problem	1

The main reasons defined by villagers for the changes in flora are reforestation and government plans for plantation of specific plants (Table 8). The villagers worried about these changes because most of the villagers rely their daily earnings on forest products.

Table 8. Images on changes in flora

Perception	Number (%)
Reforestation	8
Government Plans	6
Temperature	2
Rain	1

Most of the villagers also noticed the changes in agriculture of Popa area. Local villagers thought that the changes in agriculture are related to market condition and climate change. (Table 9) By using climatic and weather conditions, and market situation, cultivators of this study area change crops and agricultural practices.

Table 9. Images on changes in agriculture

Perception	Number (%)
Market	11
Climate change	10
Fertilizer use	2
Water problem	1

The villagers verified the changes in social condition of Popa area. The main reasons defined by villagers for the changes in life styles are TV programs and tourism related business (Table 10). TV programs are very influential to young villagers especially in fashion design and life style. Most of the young boys and girls want to wear modernized clothes and dresses whereas the old persons keep traditional clothes and dresses. Therefore, the villagers thought that life style is changing in the study area. It is important to consider the strong influence of modern information and communication technology on rural areas.

Table 10. Images on changes in life style

Perception	Number (%)
TV programs	8
Tourism	4
Journals	3
Increasing town residents	2

In the overall view of changes in environmental condition, main reasons include population increase, economic growth and agriculture change. (Table 11) Because of the changes in population, economy, and agriculture, physical and human environment of Mount Popa area is transformed.

Table 11. Images on changes in environment

Perception	Number (%)
Population growth	13
Economy	9
Agriculture	5
Health	1
Climate	1

Images shown on mental maps

There are 22 categories found in mental maps of villagers from Popa Village. Main features among these categories are Neighboring houses, Mountain, Village road, Pagoda, Monastery, Streams, Main motor road, Villages and Dry farms. Most of the villagers showed five items of information on their mental maps. (Table 12) However, about 21 per cent of the respondents showed images in 6 items to 10 items on their mental maps because some of them are government staffs who know the environment related to their jobs.

Table 12. Class of image frequency

Class	Number (%)
0	2 (5.3)
1-5	27 (71.0)
6-10	8 (21.0)
11-15	1 (2.7)

Most of the images are classified into point (shown as 113 frequencies), line (shown as 38 frequencies) and area (shown as 17 frequencies). Point pattern is usually notified by the villagers because points are easier to remember and demarcate on the maps. (Table 13)

Table 13. Class of image type

Class	Number
Point	113
Line	38
Area	17

According to the results studied on mental maps of the villagers of Popa Village, major landmarks are Popa Mountain, main road to Bagan, Popa Park and Popa Town. It is true that Popa and Bagan are very famous areas in Myanmar and most of the people in Myanmar know these places very well. Therefore, these are landmarks not only for the villagers of Popa but also for the people of Myanmar. Conserving Popa area is important in the national level.

Table 14. Major landmarks on mental maps

Class	Number
Popa Mountain	17
Main road to Bagan	11
Popa Park	6
Popa Town	3

Mountain and streams are perceived by villagers as their main environmental features around Popa area. They also emphasized on ponds, forest, trees and springs because these are very important for their daily life and for the future. They clearly noticed that decrease and disappearance of these things will strongly affect on their intimate physical environment and later to their human environment. Human environment mainly includes houses, village roads, monastery, pagodas, villages, main roads, farms, schools and markets and these items are directly and indirectly related to physical features. (Table 15 and 16) Monasteries and pagodas are usually located in the forests, on the hills and beside the streams. Therefore, these will be more suffered from the changes in physical environment of Popa area.

Table 15. Images on physical environment

Type	Number
Mountain	17
Steam	11
Ponds	9
Forest and trees	9
Spring	4

Table 16. Images on human environment

Type	Number
Neighboring houses	28
Village roads	16
Monastery	13
Pagoda	13
Villages	11
Main road	11
Dry farms	10
School	8
Market	6
Govt. building	3
Town	3
Clinic	3
Police station	1
Shop	1
Garden	1
Dump site	1

The study showed that the strong images of the villagers of Popa Village are neighboring houses, mountain and village roads because they use these things everyday. The places where the villagers frequently use are shown as medium images on the mental maps. These include pagodas, monasteries, streams, villages, main roads, dry farms, ponds, forests, schools and market. Most of the villagers showed these images on their mental maps and these images are also important for the daily life of the villagers. (Table 17 and 18)

Table 17. Strong Images

Class	Number
Neighboring houses	28
Mountain	17
Village road	16

Table 18. Medium Images

Class	Number	Class	Number
Pagoda	13	Pond	9
Monastery	13	Forest	9
Stream	11	School	8
Villages	11	Market	6
Main road	11		
Dry farms	10		

Images on the mental maps can be grouped as composite images in which images types are followed as land use classification. Among them, residential, transport and religious images are strongly emphasized by the villagers. Therefore, changes in these types can effectively influence on the environment of Popa area. Second most strong image groups are related to physical features. Changes in these physical features can significantly influence on environmental conditions of Popa area. Images of villagers on education and commercial are also high and the changes in these types will affect on the human environment of Popa area. (Table 19)

Table 19. Composite Images on environment

Sr.	Type	Number
1	Residential	42
2	Transport	27
3	Religious	26
4	Mountain	17
5	Streams	11
6	Agriculture	11
7	Ponds	9
8	Forest and trees	9
9	Education	8
10	Commercial	7
11	Spring	4
12	Public services	4
13	Medical and health care	3
14	Dump site	1
	Total	**169**

Conclusion

Environmental images of the villagers in Popa Village mainly covered with residential, transport and religious features. It is to be considered that these factors can influence on the villagers' attitudes and behavior and these are their focus on intimate human and physical environment. If environmental planning is carried out, it should be related to or removed these factors in the planning considerations.

The second highest attention of villagers on their environment is physical factor such as mountain, streams, ponds, forests, trees, and springs. Therefore, the implementation of environmental planning should also give attention to these variables.

The success of the environmental planning depends on the interest of local villagers and villagers' interest can also be studied in their images and perception. Therefore, mental maps are useful to measure the attitudes and behavior of the villagers in Rural Assessment. For further research, this study should be compared with other villages of the Dry Zone where the environmental conditions are quite different from this study village.

References

Saw Pyone Naing. 2007. Environmental Images of Rural People: The Case of Kyonesoke Village and Alangyi Village, Maubin, Department of Geography, University of Yangon.

Soe Myint. 2000. Environmental Restoration in the Dry Zone of Myanmar, Dry Zone Greening Department, Myanmar. 2001-2002 to 2003-2004.

Win Min Htwe. 2007. A Geographical Study on Forest Resources and Conservation in Dry Zone with particular reference to Kyaukpadaung Township, Department of Geography, University of Mandalay, Myanmar.

STRUCTURE AND FUNCTIONS OF A RIVER BANK PERIODIC MARKET IN DARRANG DISTRICT, ASSAM (INDIA)

Nityananda Deka [1], A.K.Bhagabati[2], Koichi Usami [3] and Kazuo Ando[4]

Abstract

The periodic markets in Assam, popularly known as *saptahik bazaar* (weekly market) or *hat* reflect the economic, ecological and socio-cultural conditions of the traditional agro-based areas which have little exposure to the organized market economy. The *hat* is an epitome of the local economy and tradition basically associated with the peasant life and livelihood. Many of the *hats* in the state are located on the banks of rivers. They follow some systems with respect to the layout and arrangement of shops and certain specialized functions. Based on the intensive field survey carried out during the year 2007-2008 with the help of purposively designed questionnaires, the present paper deals with the structural and functional characteristics of Balikuchi weekly market situated on the bank of the Barnadi river in Darrang district, Assam, India in the contemporary context of modernization of agriculture and socio-economic life of the people.

Key Words: Periodic market, morphology, agro-based subsistence areas, market economy, peasant, livelihood

Introduction

The periodic markets of Assam, locally known as *hat* or *saptahik bazaar* are often found to be situated on the banks of small and big rivers flowing through the state. Earlier the rivers were considered as the easy means for transporting goods and people. Moreover, the openness and natural cleanliness of the river banks attracted people's decision to locate the rural periodic markets. The markets held on a specific date of a week and at a fixed site become a central place for transaction of goods and services in the rural areas. They indirectly reflect the ecology, economy and socio-cultural characteristics of their complementary areas (Bhagabati, 1994). The periodic markets play an important role in making the village life self-sufficient in nearly all respects by mobilizing resources from producers to consumers and from surplus to deficit areas within the ecologically diverse complementary zones. It is interesting to note that agricultural and other local products transmit to urban centres and factory-made goods move down from urban centres to rural periodic markets which make the village life self-sufficient in nearly all respects (Tamaskar, 1992). By integrating the surplus and deficit areas, these markets operate not only as a spatio-temporal system to maintain a balance among the production systems but also help identify the micro-ecological zones around them and understand their interdependency. Again, as a node of the rural economy, the periodic markets reflect the demand and supply, and the flow pattern of products and indirectly the productivity of the concerned region (Braun *et al*, 1998).

1,2. Department of Geography, Gauhati University, Guwahati, Assam, India

3. Graduate School of International Development, Nagoya University, Nagoya, Japan

4. Centre for Southeast Asian Studies, Kyoto University, Kyoto, Japan

In addition to these, periodic markets act as centres for diffusion of innovation and information among the villagers. As the periodic markets operate as the central points in regards to organizing the areas, resources and people into a spatial system, the distribution and functional relationship of places and spatial range of their central services constitute the fundamental elements of the spatial organization and these have been the concerns of human geographical studies in the recent years (Jain, 1993).

However, very recently, due to the growing impact of modernization even in the agricultural and socio-economic environments, of the remote villages of the state, there have been noticeable changes in the morphological and functional characteristics of the markets (Deka and Bhagabati, 2009).

Several geographical studies on periodic markets of the Brahmaputra valley, Assam are carried out by Barthakur (1990), Bhagabati (1994), Saikia and Bhagabati (2000), Deka, *et al* (2008), Deka and Bhagabati (2009), Deka and Bhagabati (2009). The works of Saxena (2004), Jain (1993), Bhattacharya (1973), Tamaskar (1992), Braun (1998), Smith (1972), Lado (1988), Mizoguchi (1991), Ishihara and Mizoguchi (1989) in the context of India and other countries are worth mentioning.

However, a detailed study on the periodic markets is necessary in order to highlight the problems and prospects of the development of the agroecological zones within the regional agrarian framework so that proper plans and programmes can be evolved and implemented to improve the situation. This paper is an attempt to highlight some important aspects of the structure and functions of a river bank periodic market in Darrang district, Assam.

Methodology

During the year 2007-2008, a random sampling survey with a purposively designed questionnaire was conducted to interview around 100 vendors who are in agricultural business and a same number of consumers in every month of the year in order to know their places of residence, land holding size, visiting frequency and the sources of goods supplied. To represent the seasonal variation of the market function all the vendors and customers were interviewed with the same questionnaire on 15th April and 17th July, 2008. The internal structure of the *hat* was studied by plotting the location and spatial arrangement of shops along the small internal routes on a sketch. Information related to the historical development, tax structure, management etc. were collected from some personnels of the *hat* management committee and some vendors having different infrastructural facilities.

Growth and management of the *hat*

Balikuchi *hat* is located at Sonarishal village of Darrang district, Assam (Fig 1). This *hat* is situated on the left bank of the river Barnadi, a tributary of the Brahmaputra, at a distance of about 40 km from a Guwahati city and about 4 km from a small central place called Muktapur chowk. It is a weekly *hat* held on every Monday and therefore it is popularly known as Monday *hat*. The *hat* was established way back in 1951. The river Barnadi lies between two districts, namely Kamrup (Rural) and Darrang. Before the establishment of the present Balikuchi *hat* in Darrang district, a *hat* of the same name was on the right bank of the Barnadi river in Kamrup

(Rural) district. Interestingly, a clash between some people of the two districts led to the establishment of the present *hat* on the opposite side that is on the left bank of the river. A new dimension was, however, added to the Balikuchi *hat* in 1986, when the people of the locality for their convenience introduced a cattle market as an important component of the *hat*.

The trade in the Balikuchi *hat* remains mainly confined to agricultural and other local household products. It draws people from the local peasant community, government employees and petty traders. Absence of periodic markets around, inaccessibility, high population density on the one hand and notable development of agricultural sector after Independence (1947) on the other basically contributed to the origin and growth of this hat on the river bank.

A management community with representatives of the local people and traders are there to supervise various aspects of the *hat*. The tenure of the committee is one year. The out going bazaar committee, before its term is over, convenes a general public meeting to form a new committee. In that meeting the out going bazaar committee submits all their transaction records and then tender their resignation and hand over charges to the new committee elected by the people in the meeting itself. The main functions of the Hat Management Committee (HMC) are:

(i) to provide security to the properties of the *hat*;
(ii) to determine the tax structure to be imposed on the vendors;
(iii) to resolve any kind of problem faced by the *hat*,
(iv) to allot sites to the vendors;
(v) to provide necessary facilities including drinking water to the vendors and customers; and
(vi) To decide contributions to be made to the local institutions and public functions as donation from the management.

The *hat* is tendered for one year by the local Block Development Office. The contractor who wins the bid is recognized as *Mahalder*. The tender value for the *hat* for the year 2007 was fixed at Rs. 91,000.00. The *Mahalder* earns the right to collect taxes on each *hat* day from the participating vendors. However, recently the HMC has decided not to lease out the *hat* to the *Mahalder* keeping in view the large amount of money generated from the vendors, which can be handed by the HMC itself. The vendors now have to pay a small amount as tax to the management committee and the *Chowkidar* (guard) employed by the committee. The tax structure meant for the vendors varies as per the facilities enjoyed by them (Table 1) and quantity and type of goods they sell in the market.

Table 1. Rate of tax to be paid by individual vendors, 2008-09

Type of facility enjoyed	Rate of tax (per *hat* day) to guard and HMC (in Rs.)	
	Guard	HMC
Concrete stall	1.00	6.00
Thatched roof stall	1.00	5.00
Open space stall	1.00	3.00

Source : Field survey, 2008-09

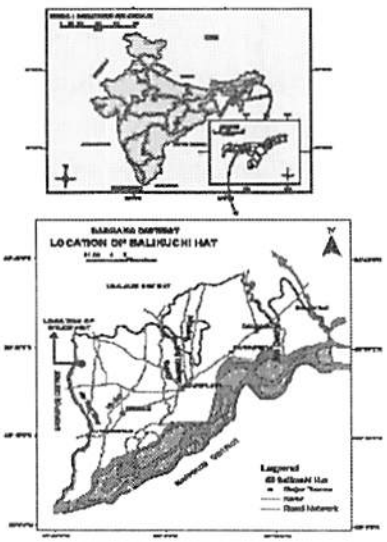


Figure 1. Location of study *hat*

Structure of the market

The periodic markets of the Brahmaputra plain exhibit certain commonality with respect to geographical location, layout, market cycle and commodity flow (Deka and Bhagabati, 2009). It is noteworthy that like other periodic markets in the Brahmaputra valley, the Balikuchi *hat* also follows some order or system with respect to layout and arrangement of the shops, especially according to the items offered for sale and certain other specialized functions (Fig 2). It is seen that the similar type of shops are located together so that consumers can make a choice for their required goods by comparing the quality and level of price of the goods.

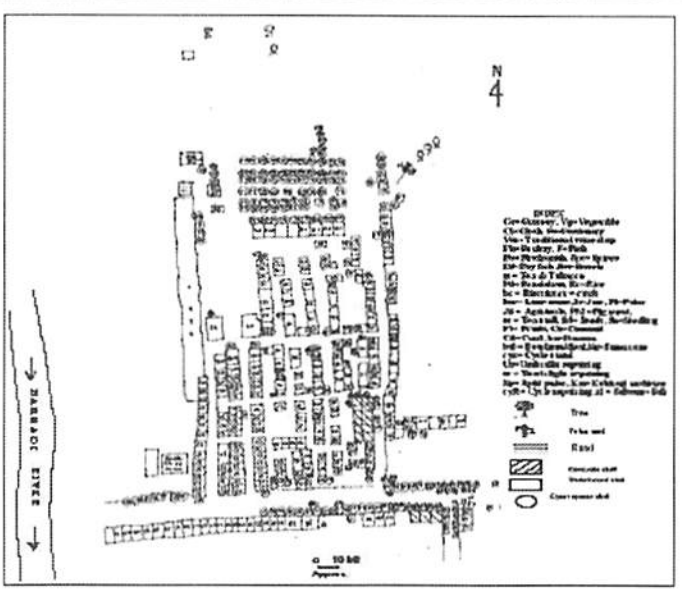


Figure 2. Layout of balikuchi *hat*

The shape of the Balikuchi *hat* is almost of rectangular. The shops of the *hat* are in a linear pattern in both the sides of the internal routes facing each other. As per the field survey carried out in the month of May, 2008, as many as 466 shops operate in the Balikuchi *hat*, which are typified by different kinds of goods (44 types) and characterized by three different housing structures. Out of the total shops, 5.58 % are under permanent structure (cemented platform with tin roof), 50.43 % are under thatched roof (*kutcha* platform with thatched roof) and 43.99 % function in open space (ground without any roof). It is seen that the big vendors dealing in rice, pulses, threads, cloths, foot wears and stationary goods have generally occupied the permanent stalls. The local farmers who sell their own products such as betel nut, betel leaves, fruits, leafy vegetables, eggs, papaya, curd, craft etc. use to sit in the marginal sites of the *hat*, generally under the shades of trees along the roads or sometimes under the shed of some big shops. This is because of the fact that the goods they carry are of small quantity and have to be visible for the customers. The shops with relatively costly goods such as clothes (11.37 %), foot wears (4.08 %), threads (1.50 %), stationery (3.86 %), biscuits (1.29 %) etc. are found to congregate in the first five rows located in the western and southern section of the *hat*. The vendors of rice (2.79 %) and pulses (2.36%) are seen in the middle part. Other important shops specialised in grocery (9.23 %), spices (3.86 %), tea and tobacco (4.08 %) are found interspersed in the central part of the market yard. The blacksmiths (0.64 %), barbers (2.36 %), mechanics of torch light (0.86 %), umbrella (1.50 %), and tailoring houses (0.64 %), tea stall (3.22 %) etc. on the other hand are located in the outer zone, especially in the eastern and southern sides of the *hat* to avoid potential sanitation problems generally associated with such kind of services. The vegetable marketing is the biggest and most distinct activity which accounts for 18.24 % of the total shops mainly concentrated in the northern side of the market yard. There are two types of vegetable traders: producer- traders who sell vegetables that they produce themselves, and the middleman traders who procure vegetables from the producers and sell in the market.

Marketing channel and resource mobilization

Like some other periodic markets of Assam (Deka and Bhagabati, 2009), the Balikuchi *hat* also manifests four distinct marketing channels through which producers, traders, middlemen and consumers perform their interrelated transaction activities (Fig 3).

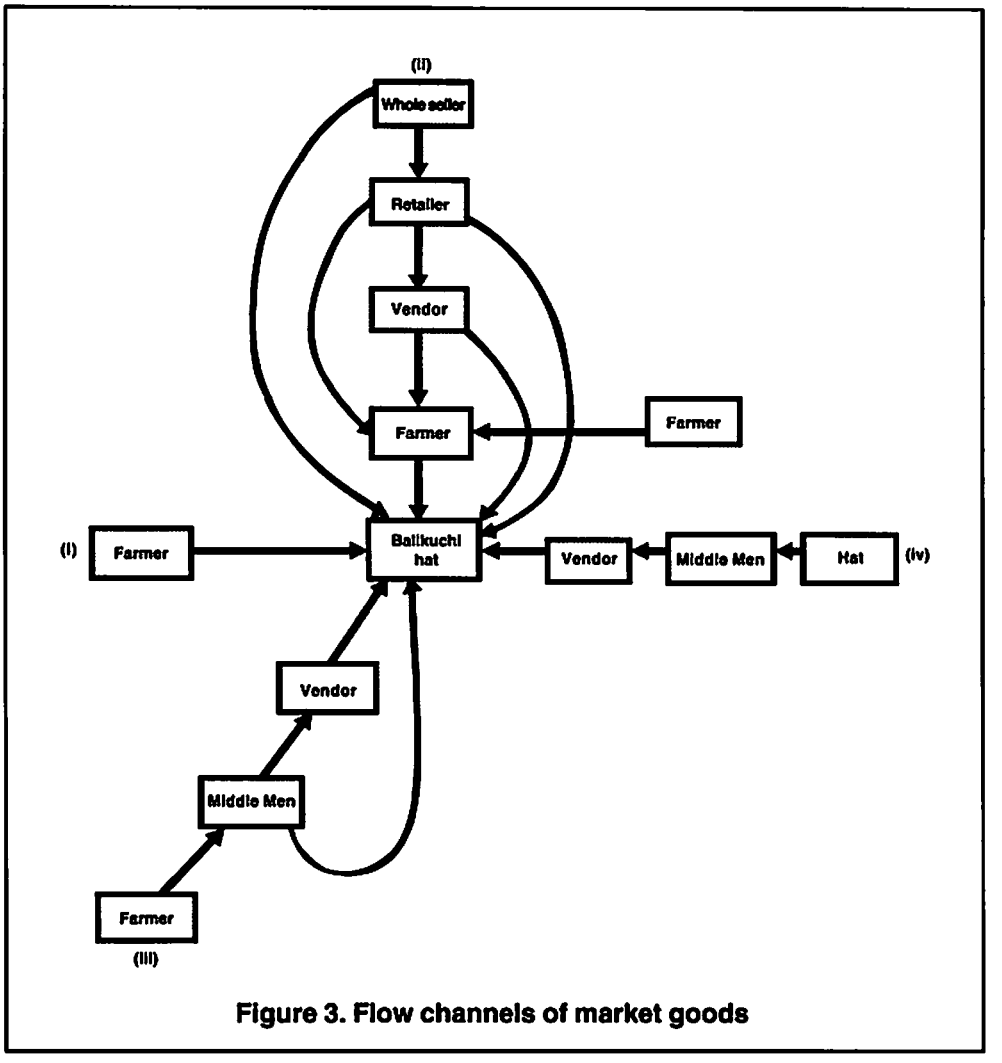


Figure 3. Flow channels of market goods

It is seen that the first channel is a straight and direct one through which the farmers sell their own products in the market. This channel is used by the producer-farmers in and around the *hat* to sell their own products, specially the perishable items such as fruits, betel leaf, betel nut, egg, leafy vegetable, curd, etc. In the second type, goods flow through a long process. The farmers collect goods either from the producer-farmers or from the retailers. The farmers in this case may directly sell the goods or play the role of intermediaries by selling the goods to other vendors in the *hat*. Sometimes, the retailers or wholesellers may directly sell their goods in the *hat*. In the third channel, the middlemen play an active role between the producers and consumers. The middlemen (*bepari*) collect the products from the farmers and directly sell the goods either

to the consumers or to the vendors. In the fourth channel, the middlemen procure goods from the big vendors either from the same *hat* or from other *hats* and may directly sell the goods to consumers or to the vendors of the *hat*. Sometimes the vendors directly purchase goods from the big vendors of the same *hat* or from other *hats* and resale these in the *hat*.

The pattern of flow of some selected commodities from different source areas is shown in the Table 2 and Fig 4. It is clear that the locally available and perishable goods are brought by the farmer-vendors from their own farmlands. Curd is the most perishable item which is mainly supplied by the farmers themselves from their own products. The commodities which are mainly brought by the vendors from their own products include curd (85.71 %), sugarcane (75.0 %), leafy vegetables (50.0 %), coconut (55.0 %), banana (60.46 %), betel leaf (57.83 %), betel nut (57.0 %), gourd (52.78 %) and rice (36.84 %), while a considerable proportion of these items is brought either from other farmers or from the same or other periodic markets. The goods which are supplied by the wholeselling shops are potato (71.57 %), onion (85.25 %), turmeric (69.23 %) etc. The items mainly procured from the same or other *hats* include tomato (36.84 %), chili (46.78 %), brinjal (53.25 %), etc. A considerable proportion of betel nut (29.0 %), betel leaf (32.53 %), onion (12.29 %) *kabi* (56.0 %), leafy vegetables (28.57 %), coconut (25.0 %) and banana (18.60 %) is also procured by the vendors from the same or other periodic markets. The goods which are procured in large quantity from other farmers are rice (23.68 %), coconut (20.0 %), leafy vegetables (21.43 %), banana (20.93 %), sugarcane (16.67 %) and *kabi* (23.2 %). It is noteworthy that there is seasonal variation in the flow of these goods depending upon the crops raised in the source areas.

Table 2. Marketing channels of some selected commodities

Commodities	Type of channel	Number of vendors in different channels				
		Producer - Hat	Farmer - Hat	*Hat - Hat*	Wholeseller– *Hat*	Total sample
Rice		14 (36.84)	9 (23.68)	8 (21.05)	7 (18.42)	38
Betel nut		57 (57.0)	9 (9.0)	29 (29.0)	5 (5.0)	100
Betel leaf		48 (57.83)	8 (9.64)	27 (32.53)	0 (0)	83
Potato		5 (4.90)	8 (7.84)	16 (15.69)	73 (71.57)	102
Onion		2 (1.64)	1 (0.82)	15 (12.29)	104 (85.25)	122
Brinjal		14 (18.18)	22 (28.57)	41 (53.25)	0 (0)	77
Tomato		12 (31.58)	11 (28.95)	14 (36.84)	1 (2.63)	38
Kabi (Three types)		21 (16.8)	29 (23.2)	70 (56.0)	5 (4.0)	125
Chili		31 (13.30)	41 (17.59)	109 (46.78)	52 (22.32)	233
Gourd		19 (52.78)	8 (22.22)	9 (25.0)	0 (0)	36
Leafy Vegetables		28 (50.0)	12 (21.43)	16 (28.57)	0 (0)	56
Coconut		11 (55.0)	4 (20.0)	5 (25.0)	0 (0)	20
Sugarcane		18 (75.0)	4 (16.67)	2 (8.33)	0 (0)	24
Banana		52 (60.46)	18 (20.93)	16 (18.60)	0 (0)	86
Curd		6 (85.71)	0 (0)	1 (14.28)	0 (0)	7
Turmeric		7 (13.46)	1 (1.92)	8 (15.38)	36 (69.23)	52
Bamboo craft		44 (68.75)	8 (12.5)	5 (7.81)	7 (10.94)	64

Source: Field survey, 2007-2008.

Note: Figures in the parentheses indicate the percentage to the total vendors interviewed.

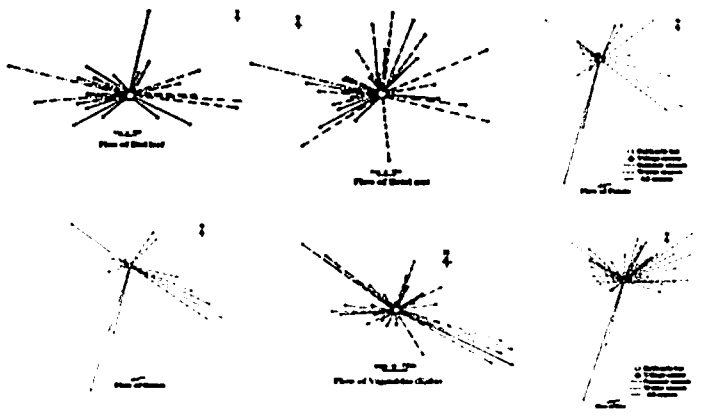


Figure 4. Source areas of selected commodities

Travel behaviour of vendors and consumers

The travel behaviour of both the vendors and consumers to the Balikuchi *hat* basically depends on the distance, road connectivity, and availability and mode of transportation. As the *hat* is located on the river banks having no good road connectivity, and most of the vendors and consumers travel on foot and by bicycle, majority of the vendors and consumers come to this *hat* from short distance. Again, the participation rates of both the vendors and customers are found to vary seasonally as significant seasonal changes occur in the cropping pattern and productivity and also the livelihood pattern in the complimentary areas.

It is interesting to note that the vendors' movement to Balikuchi *hat*, by and large, shows a radial pattern. Except for the professional vendors, who are the least in number and visit this *hat* from a distance of 55 km, the small vendors usually come from a short distance. The flow of vendors to Balikuchi *hat* as presented in Table 3 corresponds to the distance-decay function. The proportion of vendors travelling from within a range of 5 km is 65.42 %. The proportion decreases markedly with increase in distance: 19.67 % from 5 to 10 km zone, 6.9 % from 10 to 15 km zone and 8.0 % from beyond 15 km from the market.

Table 3. Distance to balikuchi *hat* from source areas of the vendors

Distance (km)	Number of vendors visiting the hat		
	Summer	Winter	Annual
0 – 5	425 (70.83)	360 (60)	785 (65.42)
5- 10	108 (18)	128 (21.33)	236 (19.67)
10 – 15	31 (5.17)	52 (8.67)	83 (6.9)
>15	36 (6)	60 (10)	96 (8.0)

Source: Field survey, 2007-2008.
Note: Figures in the parentheses indicate the percentage to the total.

Interestingly, the basic principle of central place model is applicable in case of flow of consumers to the periodic markets in the sense that the rural people use to travel only to the nearby periodic markets to cater to their requirements. The travel behaviour of consumers is, however, influenced by various factors. The attributes of the market like site, frequency, range and variety of goods, size and shape of hinterland and position in the regional hierarchy mainly control the consumers' behaviour pattern (Jain, 1993). In the case of Balikuchi *hat*, it is seen that majority of the peasants visit the market to procure goods of daily use such as food-stuffs, salt, lime, tobacco, oil, kerosene, grocery, cloth, threads, agricultural tools, seeds, fertilizers, etc. and also to repair their bicycles, bucket, umbrella, torchlight, as well as for hair cutting. Only some customers visit distant periodic markets to purchase certain special goods which are occasionally needed. Besides purchasing non-farm items not available in their villages, many of the farmers make trips to the markets for meeting their relatives, friends and also for refreshing minds and gossiping. In the Balikuchi *hat*, it is found that compared to the movement of vendors, the range of consumers' movement is quite limited (Fig 5). This is because of the fact that most of the consumers usually come to the market on foot and by bicycle, and the convenient range for them remains within about 5 km only from the market.

The highest number of consumers (91.67 %) travel from within the range of 5 km, while 5.92 % come from the range of 5 to 10 km, 1.17 % from 10-15 km and only 1.0 % beyond 15km (Table 4).

Table 4. Distance to balikuchi *hat* from source areas of the consumers

Distance (km)	Number of vendors visiting the hat		
	Summer	Winter	Annual
0-5	546 (91)	554 (92.33)	1100 (91.67)
5 – 10	40 (6.67)	31 (5.17)	71 (5.92)
10 – 15	7 (1.17)	7 (1.17)	14 (1.17)
>15	7 (1.17)	5 (0.83)	12 (1.0)

Source: Field survey, 2007-2008.
Note: Figures in the parentheses indicate the percentage to the total.

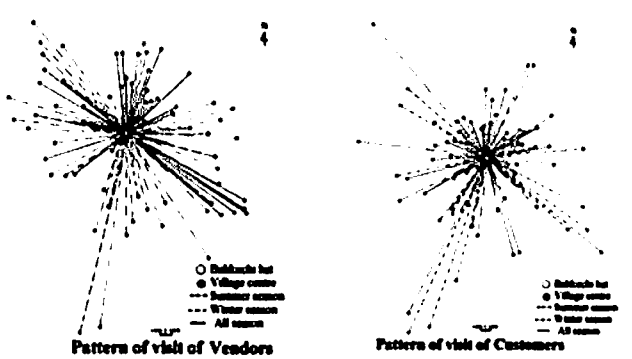


Figure 5. Pattern of visit of vendors and customers

As many as 6 categories of vendors have been identified in this *hat*. The nature and degree of flow of different type of vendors are, however, found to be different. Again, the travel behaviour of the vendors, who come from a long distance, changes slightly during winter and summer seasons (Fig 6). The participation rate of different types of vendors is also found to vary (Table 5). Table 4 reveals that the largest number of vendors (43.35 % of the total) belong to the farming community, who sell their own products in the *hat*. Out of these, 63.37 % come from within a range of 5 km, 25.72 % from 5 to 10 km, 3.50 % from10 to 15 km and 7.41 % from more than 15 km range. The next highest proportion of vendors is constituted by the businessmen (32.83 %), of which 57.61 % come from within 5 km, 26.09 % from 5 to 10 km, 5.16 % from 10 to15 km and 11.14 % from more than 15 km range. The proportion of professional traders in this market is 19.18 %. A large number of these traders (43.26 %) come from within 5 km. The other traders belong to farmer-cum-wage labourers (1.78 %), service holders and other workers (1.96 %) and others (0.89 %) categories.

Table 5. Travel pattern of vendors from different distances

Type of vendors	Number of vendors from different distance zones				
	0 - 5 km	5 - 10 km	10 - 15 km	> 15 km	Total
Typical vendor	93	73	24	25	215
	(43.26)	(39.95)	(11.16)	(11.63)	(19.18)
Farmer	308	125	17	36	486
	(63.37)	(25.72)	(3.50)	(7.41)	(43.35)
Farmer cum- wage labourer	15	2	0	3 (15)	20
	(75)	(10)			(1.78)
Service (Govt.employee,	21	1	0	0	22
priests, *thela* / rickshaw pullers,	(95.45)	(4.55)			(1..96)
drivers, painters, barbers, etc.)					
Businessman	212	96	19	41	368
	(57.61)	(26.09)	(5.16)	(11.14)	(32.83)
Others (students, old people,	9	0	1	0	10
house wife etc.)	(90)		(10)		(0.89)

Source: Field survey, 2007-08.

Note: Figures in the parentheses indicate the percentage to the total vendors interviewed

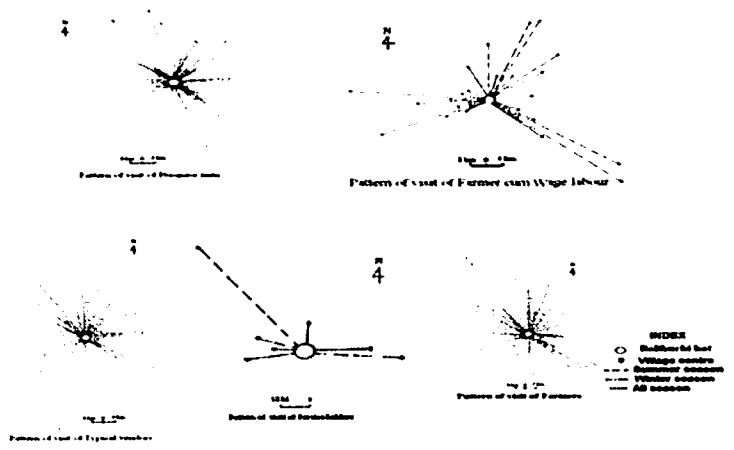


Figure 6. Travel pattern of vendors

Conclusion

The above discussion presents the internal structure and external relations, and functions of a typical periodic market situated on the bank of a river in Assam. There are a large number of such markets in the state with similar structure and functions. The present study focuses on the morphology of the market, types of shops, commodities marketed and their spatial ranges and travel behaviour of the sellers and consumers. While analysing the flow pattern of goods and the participants as well, the study finds some reflection of the distance-decay function. So far the travel behaviour pattern of the consumers is concerned, their movement is found to be limited mostly within a short-range (around 5 km from the market place). Similarly, most of the vendors visiting the market are also not from a long range. All these indicate the prevalence of a peasant type of economy in the complementary areas of the market. Importantly, the role of the market in mobilizing the local agricultural and other resources is found to be quite significant.

Acknowledgement

The first two authors extend their thanks to Professor A.K. Bora, Head of the Department of Geography, Gauhati University, Guwahati for providing academic facilities in preparing the paper.

Plate 1. Barbers engaged in dressing hair in a marginal site of the hat.

Plate 2. Vegetable vendor selling their goods

Plate 3. Pottery products in a less crowded site of the hat for sale.

Plate 4. A blacksmith engaged in meeting the need of the consumers

Plate 5. A peasant selling his home-grown products.

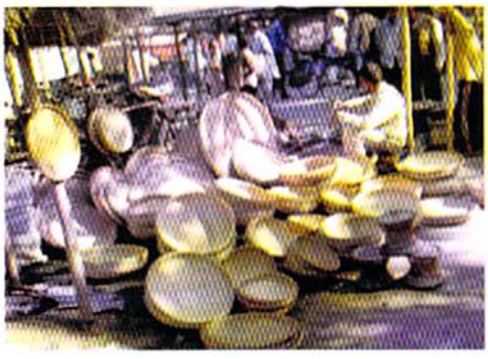


Plate 6. A vendor selling local bam boo-craft items.

References

Bhagabati, A.K. 1994. Structural and Functional Profile of Nadla Bazar: A Typical Bi-Weekly Market of the Lower Brahmaputra Valley, Assam, *North Eastern Geographer*, Vol. 25: No.1 & 2, pp.40-48.

Braun, M. 1998. Functional Change of Periodic Markets in Densely Populated Area in South East Nigeria, *Applied Geography and Development*, Vol.52: Institute for Scientific Co-operation, Tubingen, Federal Republic of Germany, pp.27-38.

Deka, N., Usami, K. and Bhagabati, A.K. 2008. Structure and Functions of Periodic Markets in the Floodplain Agroecosystem of Rural Kamrup, Assam: The Case of Kaskata *Hat*, in A.K Bhagabati (ed), *Agricultural Ecosystem andSustainable Development in Brahmaputra Basin*, Short Papers and Abstracts, International Workshop, Dept. of Geography, Gauhati University, Guwahati, pp. 47-55.

Deka, N. and Bhagabati, A.K. 2009. Role of Periodic Markets on Agricultural Resource Mobilization in the Brahmaputra Valley, Assam: The Case of Muktapur Bazar of Kamrup (Rural) District, in N.Deka (ed), *Strategy for Resource Functioning of the India's North-East: A Geographical Perspectives*, Proceedings of UGC Sponsored National Seminar, Titabor, pp.184-189.

Deka, N. and Bhagabati, A.K. 2009. Periodic Markets in an Agricultural Environment:A Case from Brahmaputra Floodplain, Assam, *Geographical Review of India*, Vol. 71: No. 4, pp. 412-425.

Ishihara, H. and Mizoguchi, T. 1989. Distribution and Characteristics of Traditional Markets, in Ishihara, H. (ed) *Markets and Marketing in West Bengal and East Nepal*, Series 3, Nagoya University, Japan.

Jain, A.K. 1993. *Marketing in an Agricultural Region*, Northern Book Centre, New Delhi, pp.60-76, 92-132, 148-157.

Lado, C. 1988. Some Aspects of Rural Marketing Systems and Peasant Farming in Maridi District, Southern Sudan, *Transactions of the Institute of British Geographers*, New Series, Vol.13: No.3. pp.361-374.

Mizoguchi, T. 1991. Traders in Periodic Markets, in Ishihara, H. (ed) *Markets and Marketing in North India*, Series 4, Nagoya University, Japan.

Saikia, L. and Bhagabati, A.K. 2000. Periodic Markets in the Rural Areas of Dibrugarh District, Assam: A Study of their Change in Distribution and Periodicity during 1971-1991, *North Eastern Geographer*, Vol. 31: No.1 &2, pp.51-61.

Saxena, H.M. 2004. *Marketing Geography*, Rawat Publication, New Delhi, pp.182-187, 204-224, 301-303.

Tamaskar, B.G. 1992. *Fundamentals of Periodic Market-Places and Networks*, Inter India Publications, New Delhi, pp.76-104, 132-141.

STUDY ON SUSTAINABLE AGRICULTURE AND RURAL DEVELOPMENT IN CENTRAL DRY ZONE AREA

Htin Aung Shein[1]

Abstract

The Union of Myanmar has administratively 7 state and 7 regions with the total population of 56.52 million in 2006. As an agricultural country, 39.27 million people are living in rural areas engaging in agriculture. The total land areas was 167.19 mac, of which 29.35 mac was total net sown areas. Striving for becoming a peaceful and developed nation the goverment has laid down the political, economic and social objective. Rice based cropping patterns of monsoon rice-summer rice/pulses/oil seed are the most prominant cropping patterns. For the achievement of rural development, goverment has been making efforts in cooperation NGOs, INGOs and local people though formulation and designing rural development programs.

Key Words : Cropping pattern, sustainability, rural development

1. General background of the country

The Union of Myanmar is geographically situated in South East Asia. It is bordered in the north and northeast by the People's Republic of China, in the east and south by the Lao People's Democratic Republic and the Kingdom of Thailand, in the south by the Andaman Sea and Bay of Bangal and in the west by the Republic of India.

The total area of the country is about 676,756 sq.km (261,228 sq.miles). The length of the Coast line from the month of Nat River to Kawthaung is approximately 229 km (1,385 miles). The western, northern and eastern parts of the country are hilly regions being divided from other neighboring countries by forested ranges, with altitudes varying from 915 to 2,134 meters.

The climate of Myanmar is divided into three seasons: summer, rainy and cold season. Generally Myanmar enjoys a tropical monsoon climate. South west monsoon brings the annual rain from the months of mid- May to mid- October, leaving the rest of the year dry. The average annual rainfall varies inside the country depending upon the geographic locations. The daily maximum temperature reaches 40.6°C to 43.3°C in the plain area of central parts of Myanmar during the hot season while the daily minimum stays at 10- 15.6°C in the cooler season. It is considerably cooler in the hilly regions where the average daily maximum is 24.9°C and the minimum, 7.2°C.

2. Demographic features

The Union of Myanmar is administratively divided into 7 States and 7 Regions. Under the States and Regions, there are 63 districts which further divided into 324 townships comprising 65175 villages in the rural areas and 2527 quarters in the urban areas. Depending upon the ease of communication and also upon the natural topography, there are differing population densities among the States and Regions.

---

1 . Assistant Manager, MOAI, MAS, Extension Division

Shan state, the largest one occupies over 155,000 sq.km while Kayah State, the smallest one, is only about 12,000 sq. km . The total population is 56.515 million in 2006, 39.27 million is living in rural areas while 17.24 million lines in urban areas. The overall farming households are estimated to be 5.44 million. The annual growth rate in population is 2.02% in 2006-2007.

3. Governance Issue

Myanmar Governance Issue has four political, four economic and four social objectives. They are mention as follow:

(I) Four political objectives

- Stability of the State, community peace and tranquility, prevalence of law and order
- National reconsolidation
- Emergence of a new enduring State Constitution
- Building of a new modern developed nation in accord with the new State Constitution

(II) Four economic objectives

- Development of agriculture as the base and all- round development of other sectors of the economy as well
- Proper evolution of the market- oriented economic system
- Development of the economy inviting participation in terms of technical know- how and investments from sources inside the country and abroad
- The initiative to shape the national economy must be kept in the hands of the State and the national peoples

(III) Four social objectives

- Uplift of the morale and morality of the entire nation
- Uplift of national prestige and integrity and preservation and safeguarding of cultural heritage and national character
- Uplift of dynamism of patriotic spirit
- Uplift of health, fitness and education standards of the entire nation

4. Economy

According to labor force survey conducted in 1990, total employment was estimated at 10.67 million peoples of which 6.02 millions or 56.47 % was engaged in agriculture sector, which represents the largest work force among the production sectors.

Estimated employment in various sectors (Labor force survey, 1990)

No.	Sector	Numbers (Thousand)	Ratio %
1.	Agriculture	6024	56.47
2.	Mining and Quarrying	102	0.95
3.	Manufacturing	1212	11.36
4.	Electricity	19	0.18
5.	Construction	281	2.64
6.	Wholesale & retail	1687	15.81
7.	Transport & Communication	403	3.78
8.	Financial institution	29	0.27
9.	Social services	825	7.37
10.	Activities not defined	86	0.81
	Total	**10668**	**100.00**

Agriculture sector receives all round support for increase production, and as a result the value of net out put of agriculture at 2005-06 contact producers' prices was recorded at 5123443.5 million kyats in 2006-07.

5. Agriculture sector

(a) Land use and cropping pattern

Presently, there are about 29.35 million acres of net sown area in Myanmar. Expansion of new agricultural land, remaining 0.63 million acres of fallow land and 14.01 million acres of culturable land is being encouraged.

Land utilization in Myanmar 2008-09 (actual)

Net sown area	29.35	mac
Fallow land	0.63	mac
Culturable waste land	14.01	mac
Reserved Forest	41.61	mac
Other Forest	40.57	mac
Other	41.02	mac
Total	**167.19**	**Million acres**

Most of agricultural land, which is about 19.5 million acre are currently cultivated by small scale farmers. The average size of holdings is 5.81 acres. Among total net sown area of 35.5 million acres 58% are held by the farm size under 10 acres.

Based on the main types of land and rain-fed regimes, the most common cropping pattern in delta and coastal regions under rain-fed condition, can be regarded as rice based cropping system, in which rice is the only choice as the first crop in rainy season and followed by oil seed crops or pulses depending on the availability and extent of residual soil moisture. The common cropping pattern being practiced in the lower Myanmar are described as follow.

Major cropping pattern in myanmar

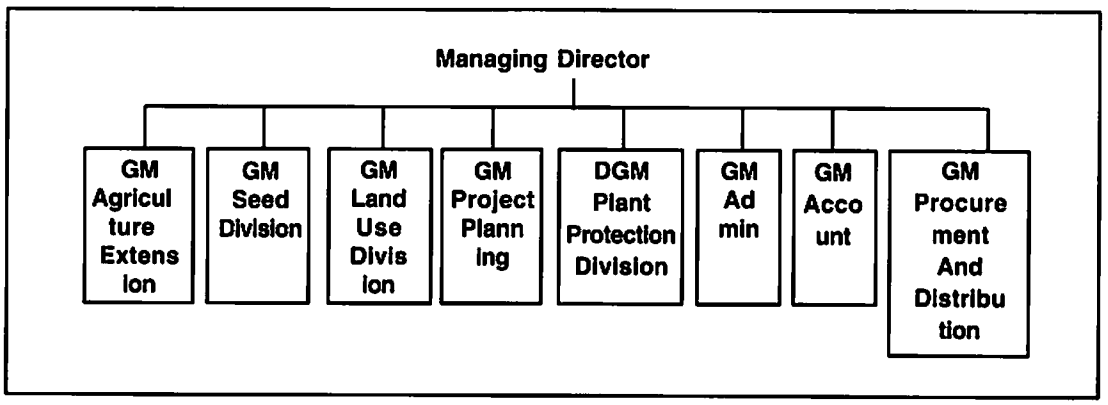
First Crops	Second Crop	Third Crop
Monsoon rice	Pulses	-
Jute	Monsoon rice	Pulses
Monsoon rice	Summer rice	-
Monsoon rice	Pulses	Summer rice
Monsoon rice	Pulses	Vegetables
Monsoon rice	Vegetables	-
Monsoon rice	Oilseeds	-
Oil seeds	Monsoon rice	-
Oil seeds	Oilseed/ Pulses	-

(b) Agricultural development polices

Polices conducive to the important of agriculture sector leading to the uplift of national economy are laid down by the MOAI.

- To allow freedom of choice in agricultural production
- To expand freedom of choice in agricultural land and to safeguard the rights of farmers
- To encourage the participation of private sector in the commercial production of seasonal and perennial crops, and distribution farm machineries and other inputs.

(c) Organizational structure for Implementation of agricultural polices



GM = General Manager
DGM = Deputy General Manager

The main function of MAS (Myanma Agriculture Service) is concerned with agricultural related applied research and extension activities, with the objectives directed towards:

- To increase the production of major crops
- The transfer of appropriate agro- technologies
- Recommendation and provision of agricultural inputs
- Soil classification and conservation technologies for sustainable crop production

(d) Transfer of technology

The transfer of technology to farmers through agricultural extension regarding crop cultivation practices, appropriate cropping patterns, provision and proper utilization of agricultural inputs, and systematic plant protection practices are being undertaken.

- Large- scale demonstration plots and block- wise crop production zones are launched at the entrance and exist of each township.
- The 10 member farmers groups are organized in each village for dissemination of technologies.
- Farmer education activities include use of media (newspaper, radio, television, journal) distribution of education pamphlets, training and visit by extension workers in groups individually.

(e) Issues regarding sustainability in agriculture sector: major problems

- Shortage of competent human resources in the agricultural research and development activities
- Lack of financial or physical access of the farmers to available inputs
- Lack of marketing system that guarantee a fair share of benefit for all parties
- Availability of genuine and quality seeds, pesticides, fertilizers, reliable tools, implements and machineries
- Transfer of appropriate and sustainable agro- technology which are environmentally friendly

(f) Policy approaches and options to tackle the sustainability issue

- Some agricultural policies related to the important industrial crops (cotton, sugarcane, rubber) were previously changed for the better performance of producers and development of the local market activities.

6. Rural development

Rural development is used to denote the actions and initiatives taken to improve the economic and social life of a group of people living in non- urban neighborhoods, countryside and remote villages. It involves extending the benefits of development to the poorest among those seeking a livelihood in such area.

6.1. Major dimension of rural development programme and policies

Rural development is Myanmar were traditionally associated with centralized planning and management in the past. The recent shift in rural policies represents a fundamental change in policy objectives and the policy framework towards a more holistic approach to reality. In addition, the policy shift towards integrated rural development reflects the complex linkages and interactions within the system of overall rural development.

Major dimension of rural development is an ongoing process involving outside intervention and local aspirations aiming the betterment of groups of people living in rural areas and to sustain and improve rural values through the redistribution of central resources, reducing disadvantages and finding new ways to reinforce and utilize rural resources.

6.2. Achievements of rural development programmes

Myanmar possesses a huge potential for pro-poor growth under the effective development and utilization of natural resources. The majority of the Myanmar people live in rural area and they mostly rely on agriculture for their livelihood. They lead a simple and peaceful life to make much more betterment for their individual prosperity. Under the circumstance, with the aim to accelerate growth, achieve equitable and even development and to narrow the socio- economic disparity between urban and rural areas, the government has been making effort in cooperation with NGO, INGO and local people while fulfilling all the necessities of rural populace by formulating and designing integrated rural development programmes.

- Ensuring smooth and better transportation
- Drinking safe water for rural populace
- To improve the education standard
- To improve rural health care system and
- To ensure the economic development for rural area

6.3. Organization structure and Implementation procedures

The majority of households living in rural area earn their income from agriculture, followed by wage labour (seasonal labour) in agriculture. Thus, Myanmar tends to be characterized as a country organization structure where skilled agricultural workers dominate the human landscape and where agricultural implementation procedure remains the substantial occupation.

The implementation procedures for agriculture rural development are:

- Local and overseas training for the uplift of technical capacity of national scientists
- Transfer of appropriate technology based upon farmers' need assessment
- Micro- financing schemes for resources poor farmers
- To formulate and implement integrated rural development programmes
- To enhance private public partnerships in agriculture

- To generate agricultural market information service for the benefit of producers, traders, farmers and consumers
- To establish reputable marketing centers and transport system
- Quality control service that shall monitor and enforce law against unlawful sale and distribution of un certified seeds, non- registered fertilizers, pesticides and other agro-chemicals

7. Overall assessment of country's sustainable agriculture and rural development

As Myanmar has a wide range of climatic conditions due to differing geographical position, over 60 different crops can be grown successfully such as cereal crops, oil seed crops. Pea and bean crop group, industrial crops, culinary crops group, plantation crops, fruits and vegetables crops ... etc. A gross sown area of 22.12 millions hectares has been recognized in 2007-2008 crop year having the cropping intensity of 168 percent. Growing of cereal crops covers the largest portion of the cultivated area followed by oil seed crops and pulses. For Myanmar's sustainable agriculture, the following five strategic measures have been laid down.

- Development of new agriculture land
- Provision of sufficient irrigation water
- Provision and support for agricultural mechanization
- Adoption of improved agro- techniques, and
- Development and utilization of improved varieties

Similarly to rural development involves action as below:

- Ensuring smooth and better transportation access in rural area
- Availability of safe drinking water
- Improving education standard
- Improving rural health care system, and
- Ensuring economic development in rural area

8. Conclusion

The Government of the Union of Myanmar is endeavoring for the sustainable economic growth of the country and the fruits of economic development to be equally enjoyed by the entire people. While raising the standards of living and quality of life of the people new economic opportunities are being created by adopting wide- ranging economic reform measure which includes among others, legalizing of border trade, liberalization of trade policies, allowing foreign sector development, and streamlining taxes and duties in the context of proper evolution of the market- oriented economic system. In fact, it is a long way for reducing poverty and livelihood improvement.

References

Central Statistical Organization 2007. Myanma Agriculture Statistics. Ministry of National Planning and Economic Development, Yangon, Myanmar.

Department of Agricultral Planning.Ministry of Agriculture Irrigation. 2008. Myanma Agriculture as a Glance.

Myanma Agriculture Service, MOAI. 2009. Myanma Agriculture and Current Situation of Some Major Crops.

FARMERS' CROPPING TECHNOLOGIES TO COPE WITH DRY CLIMATE, CENTRAL MYANMAR: A CASE STUDY IN YAMETHIN TOWNSHIP

Kazuo Ando[1] and Lay Lay Khaing[2]

Abstract

The farmers of the study village and its surrounding villages located in Yamethin Township of the central Myanmar have faced the problem of very scarce rainfall in 2009 and in the first half of monsoon season in 2010. They had serious crop damage due to abnormal climate, scientists and government officials in the world repeatedly state recent un-predictable climate change. This scarce rainfall problem can be considered as an un-predictable climate change. However, the farmers have tried to overcome such an "un-predictable climate change problem with seeking hint on the basis of their experience. For them, it might be "un-predictable". The farmers of Yamethin Township have flexibly changed their cropping system of Monsoon from transplanting rice cultivation to green gram cultivation or direct sowing rice cultivation. Particularly, an application of direct sowing rice cultivation for scarce rainfall situation is old tradition recorded in the British Burma Gazetteer of Yamethin (Wilkie 1934). This paper aims to point out the importance to learn experience of the farmers facing an "un-predictable climate problem". The MAS of Yamethin Township would be appreciated much for their attitude to evaluate the farmers' experience.

Key Words : Drought, direct sowing, upland crops, orchard, cropping system

1. Introduction : Background and Objective

At present, the world is facing frequent occurrence of unpredictable global environmental changes such as abnormal heavy rainfall and severe drought, etc. It is openly discussed about security against unpredictable environmental problem (EC 2008, Evans 2010). Unpredictable changes are unknown experience to not only general people like farmers but also specialists like researchers. Thus, logically, specialists are not specialized in coping with unpredictable environment changes. Frankly say, a simple logical model based on an analytical scientific methodology is not enough to cope with the "unpredictable" changes due to the lack of data. It is generally accepted that agriculture has started ten thousands years ago (Yamazaki et al 2004:1). Whenever farmers have faced the unpredictable changes of the agricultural environment surrounding farmers in the agricultural history before appearance of national governments implemented agricultural modernization policies in the world, farmers have tried to cope with these changes on the basis of their experience. Farmers have got the experiences through themselves or learned the experiences of other farmers. Farmers have re-built or re-used their technologies to adopt themselves into the changed environment. Furthermore, the organic farming and sustainable agriculture are re-evaluated as significant technologies to reduce affected agriculture damage

1. *Assistant Professor Center for Southeast Asian Studies, Kyoto University, Japan*
2. *Ph D student, Yezin Agricultural University, Myanmar*

from serious climate change (Borron 2006, Khor 2009). It can be noticed that the farmer's subjective technologies (LET: Locally Existing Technologies) are much given priority to be found for coping with environmental changing problem in the farming sites and to collect such cases , in order to get the hints for sustainable agricultural development. The wisdom of the farmers and the learning from the farmers about it are much required among the specialists. To learn from the farmers we have started the joint study project of "Integrated Study on Sustainable Agriculture and Rural Development in Central Dry Zone, Myanmar" has started at the Field Station Program implemented by YAU and CSEAS since 2008. The farmers at the study villages reported us that the recent biggest unpredictable natural environmental phenomenon was drought damage due to scarce rainfall in the first half of the monsoon season of 2009 and 2010. In the farmers' fields of harvest of chick pea(*Cicer arietiumj* L.) in the study village, Le Pyin Thar Village, Yamethin Township in Feb.2010 was mostly damaged due to drought .(Photo 1 and Photo 2) In addition to the farmers' opinion, we have observed that the figures are hanged at the wall in MAS(Myanmar Agricultural Service) office of Yamethin Township office to indicate the rice direct sowing methodologies at the dry land in MAS(Myanmar Agricultural Services) office of Yamethin Township(Figure 1). The rice direct sowing methodologies are much unusual in the central Myanmar but the rice transplanting methodologies are common.

Therefore, we have conducted our survey with the following objectives;

(1) To collect the rainfall data for verification of the scarcity of rainfall in the first of monsoon, 2009 and 2010.
(2) To understand the situation of agriculture at the study villages.
(3) To record the farmers' technological adaptation to the problems.
(4) To exam historical perspective of the LET (Locally Existing Technologies) found in the study villages with reference of the historical records of crop damage due to drought.

2. General information of the study site and methodologies

The study area is located in the Yamethin Township, Yamethin District, Mandalay Region and the village of Le Pyin Thar was selected as the study village. The topography of Yamethin Township is plain and is located in the north fringe of Bago mountainous ranges(Figure 2). As shown in Table 1, the average annual rainfall of 2000-09 in Yamethin Township is 852 mm. The minimum is 556 mm in 2009. The maximum is 1162 mm in 2006. There is large yearly variation. Table 1 shows the monthly rainfall data of Yamethin from 2000 to 2010. The yearly temperature did not as much vary as the yearly rainfall. In 2009, the Average monthly maximum temperature is 35.7^{0}C with the maximum temperature : 40.6^{0}C in April. The average monthly minimum temperature is 16.5^{0}C with the minimum temperature : 8.4^{0}C in December. The local farmers reported that the determinant for selecting the cropping patterns of the second half of the monsoon season is the rainfall for one month from mid of June to mid of July. In table 2, the crop cultivated acreage is shown. The main crops are rice and dry land crops (Green gram: *Phaseolus radiatus* L. and Chilies: *Capscium annum* L.) in monsoon season. The 30 % of rice filed in monsoon season and 100 % of rice field in dry season are irrigated from 15 of irrigation tanks or water reserves namely dams and pond constructed from British period to present as shown in Figure 3. The general questionnaires'survey for all the households was conducted at the study village (Le Pyin Thar Village) in 2008-09. We interviewed the farmers working in the fields of the study village and its surrounding villages and MAS staff in 2009-10. The statistic data and the reports from MAS were referred.

3. Result and Discussion

3.1. Socio-economic characteristics of the study village

The total household number of the study village (Le Pyin Thar (is 193 and the total population is 891) Male:461, Female: 430. Within 193 HHs, the main occupation of the household head of 154 HHs is farmer. The family labor force number whose age is between 18 and 60 years is 52, Male:294, Female: 231). The number of person engaging non-farming occupation 64 (Service 29, Commercial Business 26, Others 9). The most of the villagers are conducting the farming as main livelihood. According to Table3, in the study village, the lowland is called Le, where rice is mainly grown. The dry land is called Ya, where upland crops namely green gram, chickpea and sunflower etc are mainly grown. The orchard is called Uyin, where betel, grape and citrus etc are mainly cultivated. In homestead garden, vegetable and maize etc are mainly planted. Table 4 shows agricultural implements available in the study village. Tools and machines for tillage are very few, while the water pump and sprayer are much. The reason is that tillage tools can be rented /hired in cash, kind or free among the villagers. The cost of rented/hired tillage is 37,045 Kyat per hectare by a plough and a harrow. The cost of 400,00 Kyat per hectare is done by a power tiller. However, the water pump for irrigating orchard and Homestead with well and sprayer is also used for spraying agricultural chemicals in orchard and homestead. Compressor is used for water pump. In the study village, a traditional tillage method is common as shown in Photo 3 and Photo 4.

3.2. Cropping systems coping with unstable rainfall

Table 5 shows the main cropping systems of the study village. When the rainfall of June and July is scarce, green gram continuously grows instead of transplanting rice in the study village. On 29 July 2010, green gram or intercropping of green gram and sun flower were only observed. In rainy season of 2010, any farmer of the study village has not transplanted rice. According to Table1, the farmers of the study village have same experience of very little rainfall in July in 2009 and 2010 successively. The village head has talked us that the farmer always prepared the seedling beds and sown the seed to be ready for transplanting rice seedling at low land or Le. However, if there is not enough rainfall, the field cannot be well prepared because of not being enough wet or inundated for preparing the soil for transplanting. The seedlings at the seedling beds are abandoned without transplanting. The other farmer comments that it commonly happens in the village. Therefore the government has provided irrigation cannels from artificial tanks or dams. However, the rainfall has been not enough even for keeping water in the tanks several years. Since several years ago, the village has not enjoyed the irrigation water. Presently rice has being dependent on rainfall only. On the basis of this comment, we can understand that the study village has usually depended upon the unsustainable rice and dry land crop cultivations. To cope with this problem, the farmer recently developed grape, betel leaves, vegetables etc in orchard and homestead garden. At present, the main agricultural activities of the study village are orchard cultivation in terms of the farmer HHs number engaging orchard cultivation and land use acreage of agriculture in the study village (Table 3).

In the study village any farmer does not practice direct sowing for rice cultivation, but the southern part of the surrounding villages has traditionally practiced both of direct sowing and transplanting methodologies according to rainfall amount in June and July. The Photo 4 shows the direct sown rice grown fields in the southern part surrounding villages of the study village. In these fields, the farmers grow usually transplanted rice. The onset of monsoon rain was too late in June in 2010. The farmers have consequently applied direct sowing methodology instead of transplanting. However, the acreage of application of direct sowing methodology has not been corrected by MAS every year. The MAS crop statistics of rice direct sowing and transplanting is only available in 2005-06. The statistics recorded that transplanting was 70% and direct sowing was 30 % in the monsoon rice fields of five extension blocks of MAS in 2005-06. However, in July, 2010, direct sowing rice and mono green gram cropping was observed in nearly 100% of the lowland or rain-fed monsoon rice fields along the national highway. The yellow or dried up rice seedlings left at seedling beds were well observed. It may be mentioned that the serious drought problem in July 2009 makes the farmers choose direct sowing and mono green gram cultivation.

Table 1. Monthly rainfall records of Yamethin Township from 2000-2010

(Unit: mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2000	0	0	8	0	165	53	15	73	301	96	0	0	711
2001	0	0	0	0	284	69	109	190	135	146	0	0	933
2002	0	0	0	0	153	103	33	163	274	93	196	0	1015
2003	0	0	0	0	150	68	73	69	183	310	0	0	853
2004	0	0	0	0	368	99	74	13	86	120	13	0	773
2005	0	0	24	0	69	166	74	104	314	210	28	8	997
2006	0	0	50	100	85	80	183	278	188	160	38	0	1162
2007	0	0	0	0	188	121	54	105	16	223	18	0	725
2008	0	0	11	58	130	183	70	56	156	130	0	0	794
2009	0	0	13	20	88	43	18	143	148	83	0	0	556
2010	0	0	0	0	83	110	25	NA1)	NA	NA	NA	NA	

Note: NA: Data is not available Source: MAS Average 2000-2009 : 852

Table 2. Crop cultivated acreage in Yamethin Township 2008-09

Crop Name	Acreage (ha)	Yeild (t/ha)
Monsoon Rice	24332	3.3
Summer Rice	632	4.6
Monsoon Sunflower	3489	0.8
Winter Sunflower	6467	0.7
Monsoon Groundnut	6654	0.9
Winter Groundnut	4891	0.9
Monsoon Sesamum	6623	0.4
Winter Sesamum	1113	0.3
Monsoon Green Gram	15934	1.1
Winter Green Gram	1383	1.0
Local Green Gram	0	0.0
Other Monsoon Pulses	1064	0.6
Other Winter Pulses	2640	0.6
Monsoon Chilli	14903	0.7
Winter Chilli	2640	0.6
Monsoon Pigeonpea	2247	1.1
Monsoon Seed Corn	1291	2.9
Winter Seed Corn	107	2.2
Winter Lablabean	2988	0.9
Chikpea	2767	1.0
Black Gram	129	0.7
Sorgum	757	1.1
Onion	512	12.5

Source : MAS, Yamethin

Table 3. Land holding size (ha) in the study village in 2008.

	Area (ha)	Percent	Famers' Household No.	Average per a household	Mazimum per a household	Minimum per a household
Lowland (Le)	44.68	39	47	0.95	2.83	0.16
Dry land (Ya)	10.012	9	11	0.92	2.43	0.4
Orchard (Uyin)	55.12	48	128	0.43	2.02	0.4
Home garden	4.86	4	19	0.25	1.21	0
Total	**114.78**	**100**	**205**			

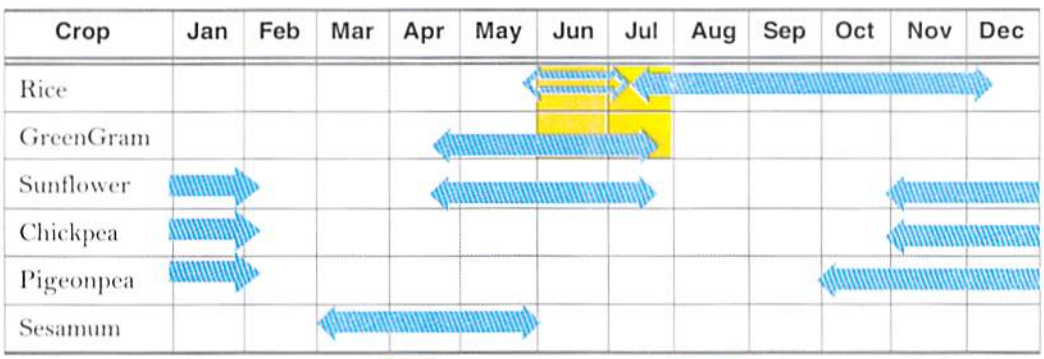
Source : Field work by Lay Lay Khaing

Table 4. Farm implements in the study village in 2008

Name of Implements	No
Bullock car	8
Harrow (Tun)	6
Plough (Te)	6
Water pump	141
Sprayer	100
Compressor	2
Harrow machin (Power Tiller)	1

Source : Field work by Lay Lay Khaing

Table 5. Cropping calendar in Le Pyin Thar Village in 2008-09



Note: Authors' Field Works Seedling Bed Growing in the Plot

Plate 1. Harvest of Chickpea

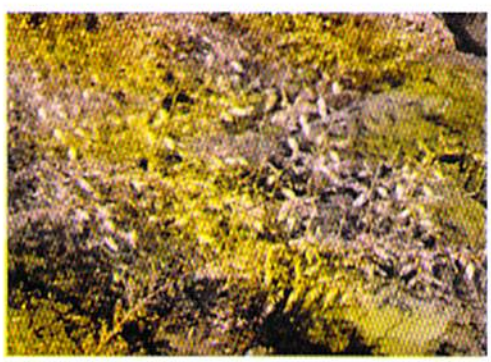


Plate 2. Most Chickpea pods were empty, dried up

Plate 3. Traditional ploughing by Te

Plate 4. Traditional harrowing by Tun

Plate 5. Green gram and sunflower (intercropping) are grown instead of rice

Plate 6. Direct sown rice growing fields instead of transplanting

All photos by Kazuo Ando on July 29,2010, Yemethin, Myanmar

4. Conclusion

In the British Burma Gazetteer of Yamethin district compiled by Wilkie (1934:10-11, 55-74), the following points are clearly mentioned; The northern region from Tatkonŷright bottom in Fig 3) was considered as a typical dry climate region. The famine occurred in 1800s due to scarce of rainfall. The years of 1901-02, 11-12, 12-13,18-19,19-20,31 were drought year due to the late onset of monsoon and the scarce of rainfall. It is recorded that the dam was broken by heavy rain in 1926-27 season. The British government opened the government farm for agricultural development of the dry zone in Tatkon. The British Burma gazetteer also recorded that direct sown rice methodology was adopted by the farmers when the onset of monsoon was delayed.

The above records proved that the present farmers' cropping systems against the scarce rainfall of the fist half of monsoon has been their counter measures since old time, at least, 80 years ago. Now, climate change or unpredictable environmental changes are frequently pointed out by scientists and government officials in the world. However, the case study reported by this paper is raising the question; to whom is the environmental change unpredictable or un-experienced? , how and who must cope with the unpredictable or un-experienced change from the views of persons concerned in the problem. The farmers and the agricultural extension workers facing the problem at the fields must obviously devise cropping systems on the basis of their similar experience in their memories and heritage from the ancestors in their community, even though the problem is unpredictable. According to our own observation in Yamethin district in 2009 and 2010, MAS has tried to highlight the experience of the farmers. It should be appreciated. We believe that "unpredictable" is able to be coped with by the farmers to seek their field experience overlooked by the scientists who have tendency to underestimate the farmers' field experience due to not being scientific. It is really requested for the scientists to be modesty to listen from farmers like MAS in Yamethin.

Acknowledgment

Our thankfulness must go to the farmers of the Le Pyin Thar village and its surrounding villages for their kind collaboration to our field works and also to the authorities of the ministry of agriculture, DAP (Department of Agricultural Planning), MAS, the government of Myanmar and the Yezin Agricultural University for their kind consent to our filed station project, particularly, collaboration to our filed survey and collecting the statistic data from MAS.

References

Borron, Sarah 2006 Building Resilience for an Unpredictable Future :
How organic agriculture can help farmers adapt to climate change FAO (Sustainable Development Department): http://ftp.fao.org/docrep/fao/009/ah617e/ah617e.pdf

EC 2008 Climate change and international security (Paper from the High Representative and the European Commission to the European Council): http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/reports/99387.pdf

Evans, Alex 02010 Resource Scarcity, Climate Change and the Risk of Violent Conflict (World Development Report 2011 Background Paper) World Bank: http://siteresources.worldbank.org/EXTWDR2011/Resources/6406082-1283882418764/WDR_Background_Paper_Evans.pdf

Khor, Martin 2009 The food crisis, climate change and the importance of sustainable agriculture (Environment & Development Series 8)TWN(Third World Network): http://www.twnside.org.sg/title/end/pdf/end_8.pdf

Yamazaki, Koou et al. 2004 The Agricultural encyclopedia (New Edition) (Shinpen Nougaku Daijiten) Yokendo co.(in Japanese).

Wilkie,R.S. 1934 Burma Gazetteer the Yamethin district. Volume A, Govt. Printing and Stationery, Burma.

FLOOD POLICY AND PEOPLE'S PARTICIPATION IN BANGLADESH

Haruo Uchida[1] and Kazuo Ando[2]

Abstract

Bangladesh has been helped by foreign aids financially not only for emergence relief for flood damage but also for establishing flood policy. We must care the fact that there are such foreign aids on the background of the flood policy of Bangladesh. Although the past ideological perspective of aids for the flood policy was mainly occupied by the idea of "flood control", it has become to be occupied partly by the idea of "living with flood" at the present day. Under such circumstance, the flood policy of the Bangladesh government must depend on ideologies for the flood among the donors. Dispute on the flood policy of this area has started in Pakistan period. In the aftermath of devastating floods in 1950's three international groups suggested that flood should be deluged but not enclosed in embankments. Nevertheless, master plan for water resource development of East Pakistan consisted of FCD/I projects with many and large embankments. Although small-scale irrigation project became the mainstream of the policy, these FCD/I projects were continued even in Bangladesh. Embankments caused the poor drainage and public-cut occurred all over the country, which induced rethinking the master plan itself in the late half 1980's. But after devastating floods in 1987 and 1988, consequently the government shifted the water policy to large-size flood control projects again. Responding to such situation, Flood Action Plan (FAP) of which the mainstream was construction of embankments started in 1989. On the way of FAP, people's participation has been highlighted but it was merely the playact without substance. After FAP the mainstream of water development policy of the government seems to be an integrated one which aims not only construction of embankments. Farmers in Bangladesh have thought how to adjust themselves to floods. They have been developing their knowledge which can be called as "local existing techniques" in order to face the flood. The traditional transplanting technique of Local Variety (LV) *aman* rice seen in *haor* at the period of water receding is a technique which is adaptable subtly to the dynamic hydrological condition. Farmers of a village are trying to recover the damage of flood by their traditional agricultural technique using LV varieties even in these days when High Yield Variety (HYV) rice is very popular. In the same village farmers cultivate *rabi* (winter crops) in normal years but increase cultivated area in flooding year. After the flood of 1987, total *rabi* cultivated area was two times larger than the former year. The fact that the *rabi* cultivated area increases on large scale after *aman* rice cultivation is damaged by the flood can be seen in many areas of Bangladesh. This kind of farmers' activities also can be thought as one of adaptive techniques to the flood. One farmer is reported to plant vegetation on the ridge of riverbed to protect the riverside near his house. It is clear that efficiency of such simple and small scale technique is less than so-called modern technology. But it is sure such kind of a technique suitable for a farmer who is not rich. It is to be desired that researchers are finding and collecting such local and/or indigenous techniques more intentionally to utilize in the field of rural development. Most of Bangladesh population is living in rural area as farmers. Flood policy suggested by farmers' successful experiences can be close to their heart and encourage them to participate in it. It is the first step to develop people's

1. *Shikoku Research Center, WeNARC, NARO (Zentsuji, Kagawa 765-0053, Japan)*

2. *Center for Southeast Asian Studies, Kyoto University (Kyoto, Kyoto 606-8501, Japan)*

participation that evaluating the farmers' experiences of flood adaptation techniques and learning from their knowledge seriously. International aids for floods must be used to make people possible to "live with flood".

Key Words : Flood Action Plan (FAP), Bangladesh, Locally Existing Technogies (LET)

Introduction

Bangladesh is located on Bengal delta which is known as the biggest delta in the world created by three big rivers of the Ganges, the Brahmaputra and the Meghna. In the rainy season, the spilled water from these three and other rivers of varying size crisscross the delta and the rain water cover the country to inundate widely. Although we may think the country suffers the flood every year considering such hydrological condition, Bengali people distinguish between the normal flood occurring annually and the harmful flood for several years. They call the annual level flood as *borsha* which warrants the traditional rice cultivation, soil fertility and the fishery. They are grateful to *borsha* as a boon of nature and, on the other hand, they call the harmful flood occurring in decades as *bonna* which damages their livelihoods. Thus we must understand the dual nature of the flood, namely a boon and a disaster,that Bengal delta gives.

*Bonna*s have caused damage to the people like as cyclones which attack coastal areas and, at the same time, have brought pressure on the central government finance. It has been frequently reported by news media that many countries and international organizations gave the emergency relief when the flood occurred in Bangladesh. Not only giving the emergence relief foreign countries and international organizations has supported the Bangladesh government financially to make the flood and water resource policy. We must care the fact that there are such foreign aids on the background of the flood policy of Bangladesh. Although the past ideological perspective of aids for the flood policy was mainly occupied by the idea of "flood control", it has become to be occupied partly by the idea of "living with flood" at the present day. Under such circumstance, the flood policy of Bangladesh must depend on ideologies for the flood among the donors.

History of flood policy

1.Pakistan period

Floods known worldwide Although there had been little flood policy of the government of East Bengal in British era, floods in this area gathered world attentions after the independence of Pakistan. In the aftermath of devouring three years' floods in 1950s', Krug mission from the United Nations, Hardin who was ex-chairman of the Mississippi committee and professor Chisse from Netherlands reported to the East Pakistan government about the flood policy. Both of Krug and Hardin offered the suggestion that the flood should be allowed to deluge. Professor Chisse also objected to enclose unstable rivers in embankments without sufficient research. It is notable that all of them didn't recommend to enclose rivers in embankments for the flood control.

Water resource development Master Plan EPWAPDA (East Pakistan Water and Power Development Agency) ,which was the newly-established administrative body responsible for water resource and power generation followed by the Krug mission report, started to implement the flood policy from 1959 actually. EPWAPDA drew up the water resource development master plan for 20 years in 1964. Large scale 58 FCD/I (Flood Control, Drainage and/or Irrigation) projects with embankments of thousands miles in length including along the three big rivers, more than one hundred polders, numberless sluice gates and other water facilities were centered on this master plan. Total expense was thought to be running at two billions of which one third should be from foreign aids. Originally this master plan aimed to attain the food self-sufficiency in 1975 as the interim goal, at the same time, the plan made the flood to be controlled by embankments.

2. Independence of bangladesh to 1989

Inherited Master Plan Although the water resource development policy focused on small projects of small-scale irrigation for expansion of food production after the independence of Bangladesh in 1971, the large-scale FCD/I projects of EPWAPDA's master plan was inherited by BWDB (Bangladesh Water Development Board) to be continued. The embankment has increased in length from 12km in 1947 when East Pakistan established to 7,555km in the last half of 1980's and water facilities has increased to more than eight thousands in numbers. 191 FCD/I projects have finished until 1987 and it was said that the half area of Bangladesh would be surrounded by embankments if ongoing 114 projects would be completed. Moved soil for construction of these embankments is expected to amount to the maximum level in the world, which indicates the flood policy has been depending on the embankments.

Imprisoned water FCD/I projects supported by foreign aids has run into trouble by and by. Constructed embankments have enclosed water in. The network of rivers and canals spreading all over the country has been cut by embankments in thousands parts to cause poor drainage, which induced rethinking of EPWAPDA's master plan itself in the late half of 1980's. After the consecutive devastating floods in 1987 and 1988 the Bangladesh government has shifted the water policy from focusing on small-scale irrigation projects to large-size flood control projects. And shifting the policy of the government had enforced foreign donors to rethink the solution of flood problems in Bangladesh.

3. After 1990.

Flood Action Plan In the aftermath of floods in 1987, 88 the Bangladesh government appealed the necessity of long-term flood policy to the world. Responding to it France and UNDP (United Nations Development Program) have made plans for controlling floods by the construction of large-scale embankments, and USAID (United States Agency for International Development) have designed the plan for living with floods without construction of embankment. Basing on these plans fifteen countries and international organizations has started FAP (Flood Action Plan) in December 1989 by the intercession of World Bank.

Mainstream of the FAP put emphasis on construction of embankments including along the Brahmaputra and the Megnna rivers, protecting large towns and tide wall against cyclones. Only two programs of 26 FAP programs were seeking countermeasures to floods with assumption of "living with floods". The idea of coexistence with flood was in a minority absolutely.

Two problems hold by FAP Most of information about FAP had not been known by citizens at starting period in the country. But home and foreign NGOs have revealed many troubles with implementing programs, which has brought about heated controversies. One of the topics of dispute was whether basic recognition to floods should be "control" or "coexistence". This was similar to the discussion by Krug and others whether floods should be enclosed in embankments or not. And another main topic of discussion was "people's participation", which had relations with citizens.

Public-cut Necessity of the people's participation has been highlighted by FAP ironically which had been implemented without people's seeing. A FAP program researching on completed FCD/I projects revealed the fact that "public-cut", which farmers cut the embankment to drain flooding water, had occurred all over the country. FAP had to recognize such ironical movements that people cut embankments protecting themselves had roots in the absence of people's participation to making plan and doing maintenance of embankments. Starting from this case many reports asserting necessity of the people's participation have been published and FAP has even formulated the guideline for people's participation. After then, FAP tried to grant local people's wish for projects and technical experts engaged in projects showed their efforts to contact with local people in their daily activities.

People's Participation In spite of highlighted people's participation, FAP has been implemented neglecting the local people from a practical point of view. For example, it was reported that FAP has decided to construct the embankment one-sidedly and stopped scheduled meeting with local people although villagers had wanted "the drainage system" instead of construction of embankment in answer to preliminary research of FAP. Moreover, there had been no female and landless member in water utilization association inside of FAP embankment. In this case, evaluation committee of the donor country criticized as if all villagers of the area only consisted of land owner and a critical lawyer group accused this situation as the human rights issue. Thus, people's participation of FAP was merely an apology to the world.

Farmers' adaptation to floods

Rural areas of Bangladesh have been damaged by floods around the same time that the government implemented the flood policy supported by the embankment construction. As *bonna* cannot be controlled privately or even communally, farmers have thought how to adjust themselves to floods. They have been developing their knowledge which can be called as "local existing techniques" in order to face the flood.

Adaptation to flood by *Aman* rice variety

In J village which is located on the fringe of *haor* or big seasonal inundated area farmers cultivate *aman* rice on *kanda* which is classified into high, medium and low-field. HYV (high yield variety) is cultivated in the high-field, LV (local variety) in the low-field and both varieties are cultivated in the medium-field. It is one of characteristics of *aman* rice cultivation in the village that LV in the low-field is transplanted at the water receding period. And so, the transplanting in the low-field may be late one to two months than that in the high-field if water recedes slowly. This kind of variety is more photosensitive than HYV and responds to day length sensitively and, so the rice can be harvested at the end of November to the beginning of December even if rice stays in the

plot shortly. In the flooding year the farmers transplanted LV *aman* rice in the part of medium- and high-field after the second transplanted HYV rice was damaged by the second flood peak. The farmers transplanted LV rice which can be transplanted lately after the second flood peak even in the high-field. Increase of LV rice area in the flood year shows that the farmers elected rice variety to adapt to the dynamic water condition.

In Bangladesh, HYV rice has been considered to take the place of LV rice used in the low-yielding traditional transplanted *aman* rice cultivation. Nevertheless, we can understand the traditional transplanting technique of LV at the period of water receding is a technique which is adaptable subtly to the dynamic hydrological condition. The farmers of J village are trying to recover the damage of flood by their traditional agricultural technique using LV varieties even in these HYV is popular days to realize the stable *aman* rice cultivation.

Adaptation to flood by *Rabi* cultivation

In J village *rabi* crops, namely dry field crops in the dry season like mustard, chili, wheat and pulse are cultivated on *kanda* where rich in sand and drains. The crops are sown from the beginning of November after reaping *aman* rice, in some cases the field is in fallow during the *aman* season, and are harvested in January and February. *Rabi* crops have been cultivated traditionally using water hyacinth brought by floods as manure. After the flood of 1987, total *rabi* cultivated area was two times larger than the former year as shown in Table 1 and mustard cultivated area was three times and chili area 1.8 times. Not only on the field of *kanda* which was given up to cultivate *aman* rice but also on the fallow field in the former year *rabi* crop was cultivated newly and, in consequence, total cropped area became 10ha larger than that of abandoned *aman* field.

Table 1. Rabi cropped area in the no-flooding and flooding year (ha)

Rabi crops	No-flooding year(1986/87)	Flooding year (1987/88)
mustard	41.8(38%)	128.0(64%)
chilli	19.8(18%)	32.2(16%)
wheat	26.4(24%)	9.9(5%)
pulses	15.4(14%)	23.7(12%)
others	6.6(6%)	6.2(3%)
Total	**110.0(100%)**	**200.0(100%)**

The inundated area in the middle of October in 1987 of the flooding year was larger than that of the former non-flooding year and water receded rapidly afterwards. Especially, the water recession from *kanda* which is suitable land for *rabi* cultivation was remarkable at the beginning and the middle of November when mustard was sown. Thus, a great deal of water hyacinth carried by the big flood and the water recession just in time brought abundant manure and moderate soil moisture good for *rabi* crops, especially, mustard in 1987/88.

The fact that the *rabi* cultivated area increases on a large scale after *aman* rice cultivation is damaged by the flood can be seen not only in J village but in many other areas of Bangladesh. The bigger flood followed on the heels of the flood in 1987 and rice cultivation in the rainy season was damaged further in 1988, nevertheless, it is said the agricultural production reached nearly a record in 1988/89. This is showing the flood damages the agriculture in the rainy

season and, on the contrary, guarantees some of cultivating conditions in the dry season. Namely, the flood in Bangladesh is a constraint for the agriculture and, at the same time, is also a condition which can keep the balance of agricultural production.

Plant using for riverside protection

One farmer who lives on the riverside of Rowhajon river in Tangail district planted three kinds of vegetation on the ridge of riverbed. His purpose is protecting the riverside on which his homestead situated from water flow. He planted *dor-kormi* on the roadside and the lowest part of the riverside, *kaisha* on the medium elevating part and banana trees on the highest part of the ridge as shown in Fig.1 schematically. He planted the vegetation in the dry season of 1994 in the aftermath of continuous two years' erosion by floods in the rainy seasons.

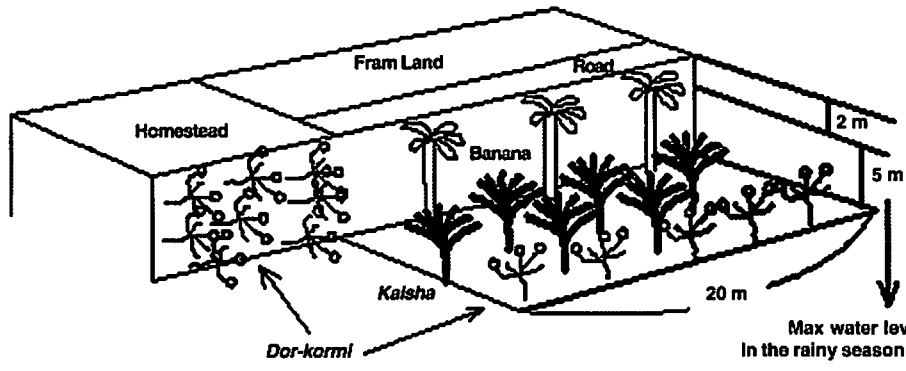


Figure 1. Planting against river erosion

He brought the cutting of *dor-kormi* which had drifted ashore and took root on *char*, or sand bar to his house and planted the cutting of 45 cm on the riverside. It can reduce velocity of water flow and also control waves. Sand and earth should deposit 90 cm thick annually if it would be planted in dense and the plant can stand even in deep water. He planted the cutting also on roadside and it grows thick over there with 3 m height at present. It is protecting his homestead from the river erosion. *Kaisha* grows about 2 m in a year. It can deposit 90 cm sediment if it could stay in water. New stalks would come from the root in the following year after cutting old stalks at the point of 40 cm above the root. It is only necessary to plant the root every four years if old stalks would be cut annually. Banana trees are planted on the riverside to protect steep cliff and roadside from erosion and to promote sedimentation. The hard roots of about 3 m long stretch in all direction under the ground of 10 cm. The root is hardly pulled out if once it rooted in the ground by waves and the tree can deposit sand 80 cm thick in a year.

It is clear that the efficiency of this kind of simple and small scale technique is less than so-called modern technology. But, at least, it is sure such kind of technique is suitable for a farmer who is not rich because of its inexpensiveness and sustainability. Moreover, this kind of technique can be said environment friendly technique, which can be substantiated individually. It is to be desired that the researchers are finding and collecting such local and/or indigenous techniques more intentionally to utilize in the field of rural development. Such a technique that is familiar to villagers can be accepted easily by themselves and become an effective tool for rural development.

Conclusion

Aiming to live with flood

Bangladesh flood is devastating as shown by the flood of 1988 which caused heavy damage to the country and cannot be controlled only by technological measure. Construction of colossal embankments for flood control which is invested in tremendously may result in the ecological destruction in the delta and only worth for the severe flood seldom if ever. It is more realistic solution such as the construction of safe shelters, emergent food supply and medical service systems, protection of shallow inundated farmland and development of local surface water drainage that has low environmental effect and effective economically and technologically than controlling floods itself. For developing these effective measures, we must reveal more about the local measures for safety and cultivation system to expected flood damage. Namely, we have to learn from farmers how they have lived with floods.

Most of Bangladesh people are living in rural areas as farmers. Flood policy suggested by farmers' successful experiences can be close to their heart and encourage them to participate in it. It is the first step to develop people's participation that evaluating the farmers' experiences of flood adaptation techniques and learning from their knowledge seriously. International aids for floods must be used to make people possible to "live with flood".

References

Adnan, S. 1995. People's participation in the Tangail compartment. Monitor, 1(3): 12-13.

Flood Plan Coordination Organization (FPCO), Ministry of Water Resources, GoB.1992. FAP12 FCD/I Agricultural study : Final report Vol.1:3-14.

Flood Plan Coordination Organization (FPCO), Ministry of Water Resources, GoB.1994. Report on the flood action plan:S-3.

Haggart, K. et al. (ed.) 1994. Rivers of Life. Bangladesh Center for Advanced Studies, Dhaka:26.

Hughes, R. et al. 1994. Floodplains or flood plans? : A review of approaches to water management in Bangladesh. IIED and RAS, Dhaka:34-35.

Safiullah, A.M.M. 1989. Embankments for flood protection : Success and failure. In *Flood in Bangladesh* (ed. Mohiuddin Ahmed). Community Development Library, Dhaka:174.

Uchida, H. and K. Ando. 1996. Riverbank erosion control by "existing local technologies in Bangladesh. *J.JSIDRE*, 64(4):47-52[In Japanese].

Uchida, H. 1998. Natural disasters and foreign aids. (In *Foreign aids and Bangladesh.* ed. Sato, H.). IDE-JETRO, Tokyo, Japan:104[In Japanese].

Uchida, H. and K. Ando. 2003. Floods in Bangladesh : Farmers' adaptability and national policy. Journal of Asian and African Area Studies 3: 3-34[In Japanese].

Uchida, H. and K. Ando. 2007. Adaptive agricultural system to dynamic water condition in a low-lying area of Bangladesh. JARQ 41(1):25-30.

Uwagawa, M. 1991. Bangladesh mega project. Journal of Land reform, 105: 62-65[In Japanese].

IMPACT OF CLIMATE CHANGE ON CROP PRODUCTION IN CENTRAL DRY ZONE, MYANMAR: A CASE STUDY IN PHAUK-SEIK- PIN VILLAGE, NYAUNG-U TOWNSHIP, MANDALAY REGION

Lay Lay Khaing[1] and Khin Lay Swe[2]

Abstract

In these days, precipitation under monsoonal influence is more and more erratic and annual precipitation in central zone is very often fluctuating. Under many uncertainties of climate change scenarios, farmers' traditional farming practices must have some adaptation technologies to combat the harsh climate for several decades. Field surveys were conducted at Phauk-Seik- Pin village, Nyaung-U Township during the crop seasons from 2008 to 2010. To reduce the risk of crop failure, most farmers in the study village followed mix cropping patterns rather than mono-crop under the single or double cropping. Sesame, groundnut and pulses are the most common crops and farmers grow them in all three seasons of a year, namely, pre-monsoon, monsoon and post-monsoon. Among the last three years, the year 2009 designated as El Nino year, received the least annual rainfall while heavy rainfall occurred in 2010 because of the Cyclone Giri. The survey results clearly showed that insufficient rains reduced the sown acreage in all seasons while the heavy and untimely rains damaged the cultivated crops in the study village.

Key Words : Impact, dought, treaditional practice, decline

Introduction

Despite the many great technological advances in agriculture, weather and climate are still key factors in determining agricultural productivity in most areas of the world. Agriculture is one of the most vulnerable sectors affected by climate change. Climate change related phenomena include unusual fluctuations in rainfall patterns and temperatures, as well as their associated impacts on water availability, pests, disease, and extreme weather events, all of which can substantially affect the potential of agricultural prouction. The Myanmar Dry Zone has the characteristics of very low (annual rainfall of 500-700 mm) and erratic rainfall over time and space, shallow soils with low fertility and low moisture holding capacity. Generally, soils in the dry zone areas are being degraded mainly due to its topography and severe weather condition. The local farmers have long experiences of crop production under the unfavorable conditions. Their traditional farming activities must have in someway the adaptation technologies to their specific environment. Over several decades, with trials and errors, they have selected crops, crop varieties and cropping patterns which give a better yield. Location specific research is lacking in the dry zone areas and research on area study of farmers' existing crop production under the climate change scenario needs to be carried out before venturing into a new or additional crop sequences or a farming technology for the improvement of their farming systems. Therefore, a field station area study was carried out with the objectives of study on the existing cropping patterns and impact of climate change on crop production in dry zone area.

1. Ph. D student (Assistant Lecturer, State Agriculture Institute, Pwint-phyu, Magway Region)

2. Pro-Rector (Academic Affairs), Yezin Agricultural University, Yezin - Naypyitaw

Methodology

Phauk-Seik- Pin village, Nyaung-U Township, Mandalay Region was selected as a field station under the research project of the "Integrated Study on Sustainable Agriculture and Rural Development towards Research and Education". As a part of this research study, farmers' surveys and field observations on their cropping patterns and livelihood were conducted during the cropping seasons from 2008 to 2010. The primary data were collected from all farmers household in the study village (109 in total) and secondary data were gathered from the Myanmar Agriculture Service and Settlement and Land Records Department (Ministry of Agriculture and Irrigation) in Nyaung-u Township.

Survey Research Finding

The study village, Phyauk-Seik-Pin, is located in Kone-Tan-Gyi village tract which constitutes 7 villages. The demographic data, land type and land holding size, and type of houses were shown in Table 1, Table 2 and Table 3, respectively. Most of the lands are Yar type (upland) and upland crops such as sesame, groundnut, mungbean and pigeon pea are mostly cultivated. Farmers' interviews and farm equipments and livestock holdings showed that traditional ploughs and harrows were the main farm implements together with the cattle draught power used for their farming operations. For the extra income, goats and pigs were reared as a livestock breeding (Table 4). Some farmers use only organic manure of cow dung and of excreta of goats and pigs while some applied them with a few amount of chemical fertilizers. Fuel wood and water were scarce items and household and drinking water relies on the river pumping project started in 2002 (Photo 1 and 2).

The largest areas of oil seed crops (sesame, groundnut and sunflower), pulses and cotton concentrate in the central dry zone. Since the scarce and erratic rainfalls with low soil fertility enhance the risk of crop failure, farmers generally adopt different cropping patterns on a plot by plot basis to secure a reliable income. Crop yields vary year from year and plot from plot mainly depending on the rainfall and soil condition. Farmers grow mono-crop in pre-monsoon (April / May), monsoon (July / August) and / or late monsoon (September / October) seasons. Besides, multiple copping patterns (mix cropping, double cropping, relay cropping and crop rotation) are traditionally practiced with the objectives of reducing the crop losses and retaining soil fertility. Many farmers broadcast the seeds of two or more crops together at a same plot and harvest them according to their duration. The risk-averse farmers concept is that they invest the least and they will collect whatever left after the stresses. The low yields of crops generally reflect low levels of inputs and management.

Table 1. Demographic data on Phyauk -Seik-Pin village

Item	Male	Female	Total	Percentage of total population
Population	727	784	1511	
Family labor	199	196	395	26.14
Over 15 age	506	574	1080	71.48
Under 15 age	209	206	415	27.47
Schooling	119	116	235	15.55

	Farmers	Landless	Total
Number of households	109	176	285
Average landholding size (acre)	21.73		

Table 2. Type of land and landholding size

Land type	Acres	Hectare	%
Low land (le)	4	1.62	0.33
Upland (ya)	1191	481.99	99.67
Landholding	**Frequency**		**%**
Less than 5 ac.	26	10.52	23.85
5 to 10 ac.	42	17	38.53
Above 10 ac.	41	16.59	37.61

The dry zone region has a bimodal pattern of monsoon season with an interruption during July, which is locally known as July drought. Average annual rainfall from 2000 to 2010 was presented in Figure 1. It was noticed that July drought became more and more intense with longer durations since the last decade. About 10 -15 years ago, sesame were grown in April / May as a pre-monsoon crop, which is called "Moe-kyo-hnan" in Myanmar language. However, the farmers faced the increased frequency of crop failures due to the scarce rainfall. For the fear of the July drought, farmers changed the growing time of sesame to the late July / August. At present, most farmers grow their crops when the rain comes after the July drought as a monsoon crop (which is called "Moe-hnan") and in September/ October as a post-monsoon season crop (which is called "Saung-hnan"). As a traditional practice, land preparations are started after the previous crop's harvest and continued for a long period while waiting for the sufficient amount of rain. It creates to expose the bare soils susceptible to wind and water erosion at the time of high wind and rain velocity (July and August). The most widely grown crops and the crop calendar were shown in Table 5.

Table 3. Type of houses

	Roof	Wall	Floor
Zinc sheet	102		
Thetkal	4		
Wood		15	
Bamboo	70	225	
Brick		37	
Toddy palm leaf	108	7	
Total	284	284	279

Table 4. Farm equipments and livestock holdings

Farm machineries			Livestock holdings		
No.	Items	Frequency	No.	Items	Frequency
1	Bullock cart	120	1	Bullock	81
2	Plough	31	2	Buffalo	1
3	Harrow	239	3	Goat	20
4	Pump	7	4	Fowl	10
5	Sprayer	7	5	Pig	15

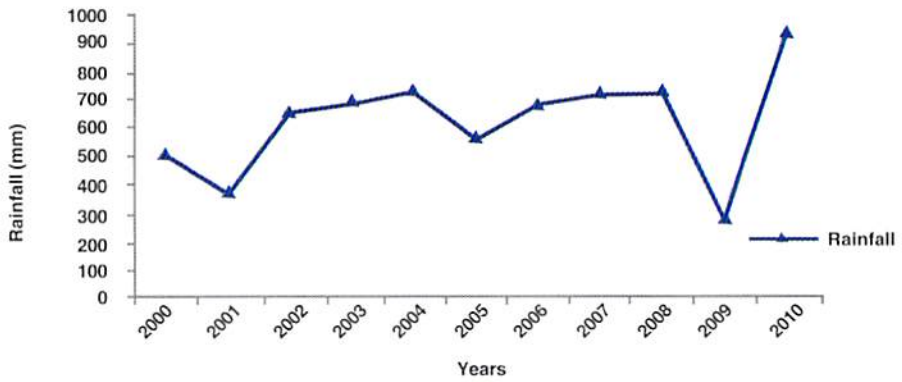


Figure 1. Average annual rainfall in Nyaung-U Township

Source : Weather Station at Nyaung-U Agricultural Research Farm

Table 5. Crop calendar in Phyauk-Seik-Pin Village

Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Groundnut												
Mungbean												
Sesame												
Sorghum												
Watermelon												
Pigeon pea												

The annual rainfall patterns in three successive years (from 2008 to 2010) in Nyaung-U Township were described in Figure 2. The annual total rainfall was 723.39 mm, 272.29 mm and 926.34 mm in 2008, 2009 and 2010, respectively. Crop failures of sesame, groundnut, mungbean and sorghum in Phyauk-seik-pin village were recorded in November, 2009 and in July, 2010 (Photo 3 and 4). The impact of drought on sesame cultivation was most severe in 2009 since it received the least rainfall among three successive years. The sesame sown areas in monsoon season were 3.64 ha in 2008 and 1.62 ha in 2009 but there was no monsoon cultivation of sesame in 2010 because of the very few rainfalls in July and August, 2010. Moreover, some villages of the Kone -tan-gyi village tract could not grow sesame in monsoon and post-monsoon in 2009 and monsoon in 2010. The post-monsoon sesame areas were also declining with 111.29 ha, 22.26 ha and 27.11ha in 2008, 2009 and 2010, respectively (Table 6).

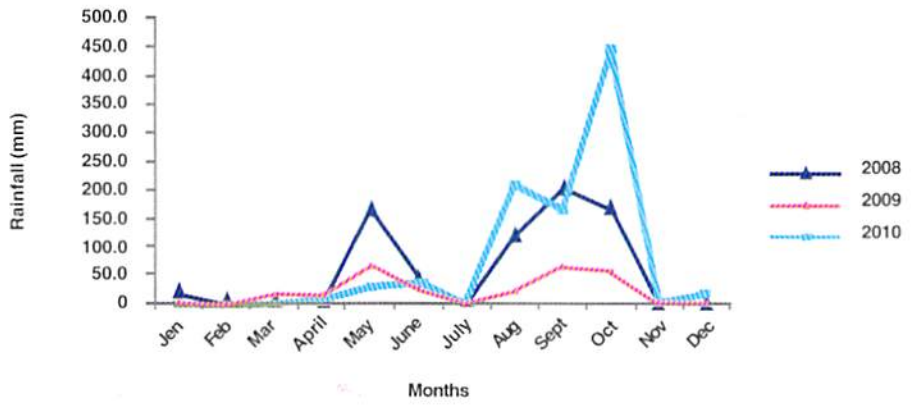


Figure 2. The annual rainfall patterns in three successive years in Nyaung-U Township

Source : Weather Station at Nyaung-U Agricultural Research Farm

Table 6. Sesame cultivation from 2008 to 2010 at Kon-Tan-Gyi Village tract, Nyaung-U Township

Village	Sesame Sown Area (ha)					
	2008		2009		2010	
	Monsoon	Post-M	Monsoon	Post-M	Monsoon	Post-M
Kone-Pha-Yar	0.81	55.04	0.00	0.00	0.00	29.95
Phyauk-Seik-Pin	3.64	111.29	1.62	22.26	0.00	27.11
Kone-Sin-Kye	0.00	2.02	0.00	0.00	0.81	3.64
Taung-Shay	7.69	141.24	0.00	10.12	0.00	44.92
Mya-Kan-Gyi (North)	10.52	22.26	12.95	0.00	4.05	11.33
Mya-Kan-Gyi (South)	18.21	27.11	4.86	0.00	1.62	11.74
Kone-Tan-Gyi	24.28	144.88	6.88	0.00	3.24	14.97
Total	**65.16**	**503.84**	**26.31**	**32.38**	**9.71**	**143.67**

In the pre-monsoon season 2010, there were only few rains in April/ May so that groundnut and mungbean were sown in all villages but only some villages grew a few sesame areas. The cultivated areas and damaged areas of sesame by drought in pre-monson, 2010 were shown in Table 7. In the Kon-tan-gyi village tract, groundnut, mungbean and sorghum were grown in monsoon, and sesame and sorghum were in post-monsoon in 2010 (Table 8).

Table 7. Area of cultivation and damage by drought in Kon-Tan-Gyi Village tract in pre-monsoon season, 2010

Village	Groundnut (ha)		Sesame (ha)		Mungbean (ha)	
	Cultivation	Damage	Cultivation	Damage	Cultivation	Damage
Kone-Pha-Yar	17.81	10.12			12.95	4.05
Pyyauk-Seik-Pin	44.92	20.23			41.28	18.21
Kone-Sin-Kye	14.16	6.07	0.81	0.81	10.52	5.26
Taung-Shay	102.79	50.59			79.32	39.66
Mya-Kan-Gyi (North)	20.23	8.09	4.05	4.05	14.16	4.86
Mya-Kan-Gyi (South)	22.66	12.14	1.62	1.62	14.97	5.67
Kone-Tan-Gyi	51.40	28.33	3.24	3.24	54.63	26.31
Total	**273.98**	**135.57**	**9.71**	**9.71**	**227.84**	**104.01**

Source : Settlement and Land Records Department, MOAI (21-7-2010)

Table 8. Sown area of crop in Kon-Tan-Gyi Village tract in monsoon and post-monsoon seasons, 2010

Village	Monsoon			Post-monsoon	
	Groundnut	Mungbean	Sorghum	Sesame	Sorghum
Kone-Pha-Yar	9.31	73.25	9.71	29.95	
Pyauk-Seik-Pin	16.59	53.01	9.31	27.11	1.62
Kone-Sin-Kye	0.81	8.90	3.24	3.64	0.00
Taung-Shay	44.52	66.77	13.76	44.92	4.86
Mya-Kan-Gyi (North)	24.69	24.28	14.16	11.33	0.00
Mya-Kan-Gyi (South)	16.59	19.02	7.69	11.74	2.02
Kone-Tan-Gyi	28.33	41.68	14.57	14.97	2.02
Total	**140.83**	**286.93**	**72.44**	**143.67**	**10.52**

Source : Settlement and Land Records Department, MOAI

In October 2010, the Giri Cyclone hit Myanmar in Yakhaine State, Magway, Mandalay and Sagaing Regions. The continuous and heavy rain occurred for about 2 weeks and amounted to 448.6 mm in this month in Nyaung-U Township (Source: weather station at Nyaung-u Agricultural Research Farm). According to the farmers' survey on 18th January 2011, it was noted that the sesame crops were severely damaged but the groundnut and sorghum gave a very good yield. It was because the cyclone-rains favored the pod formation of groundnut and growth of sorghum (Data unpublished). Sown area of groundnut and sesame in pre-monsoon, monsoon and post-monsoon in five successive years (2006 to 2010) were described in Figure 3. The sharp area decline post-monsoon sesame areas occurred up to 2010 while the other three crops are stable with the low sown crop area in general.

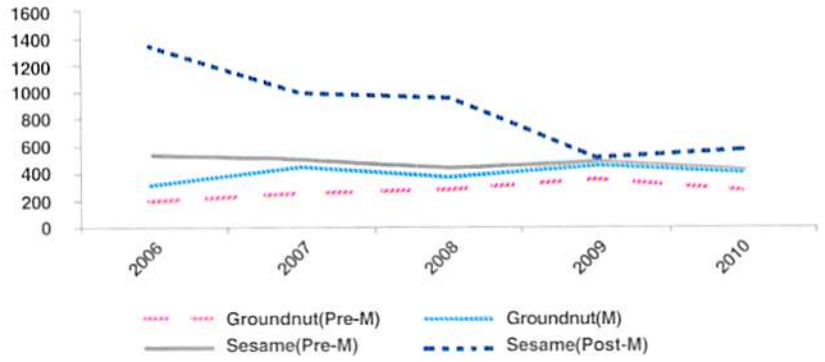


Figure 3. Sown area of groundnut and sesame in Kone-Tan-Gyi Village tract

Source : Settlement and Land Records Department, MOAI

Plate 1.To fetch water is a daily routine for drinking and household use

Plate 2. Fuel wood relies on the Toddy *and Acassia* trees

Plate 3. Groundnut plants under drought in 2009

Plate 4. Mungbean and watermelon damaged by drought in 2010

Conclusion

Agricultural practices, such as sowing dates, cropping patterns, crop varieties and their relationships with the environment are the key factors for the successful production of a particular crop. According to the surveys, it was clear that farmers are striving to harvest a good yield under their existing fragile condition. With the scarce resource of soil moisture and fertility, they prefer double cropping system to a single crop to ensure a good yield of a crop. As an adaptation measure, most farmers follow the mix-cropping rather than mono-crop, under the single or double cropping pattern, to avoid the entire crop loss by drought or untimely rain. However, due to the severe drought in 2009, farmers harvested only half of the normal production. The continuous and heavy rain in November, 2010 caused the farmers lose the entire sesame crop but gave a bumper harvest of groundnut and sorghum.

Traditionally, crop residues are mostly used as animal feed (e.g. groundnut and pulses) and fuel (e.g. sesame and groundnut), and farmers do not apply them into their fields and it leads to decrease in organic matter and fertility replenishment to the soil. Therefore, insufficient application of organic matter is a major cause of low soil fertility in the farming systems. The availability of drought tolerant varieties and irrigation facilities, access of micro credits, crop insurance system and off-farm income opportunities should be introduced for the livelihood and to overcome the impact of current and future climate change.

References

Carucci, V.F.P. 2001. Guidelines on Soil and Water Conservation for the Myanmar Dry Zone. HDI. III, MYA/99/006.

Department of Agricultural Planning, Ministry of Agriculture and Irrigation. 2010. Myanmar Agriculture at a Glance.

Data sources: Weather station at Nyaung-U Agricultural Research Farm.

Myanma Agriculture Service and Settlement and Land Records Department (Ministry of Agriculture and Irrigation), Nyaung-U Township.

REVIEW ON HORTICULTURE PRODUCTION IN MYANMAR

San San Yi[1]

Abstract

Being an agriculture based country, Myanmar economy highly relies on its agricultural production. With its diverse agro-ecological zones, a large number of crop species including vegetables and fruits grow well throughout the country. The market demand for horticulture crops has been emerged in recent year due to the population increase, improved household income, and increased awereness about the vital role of vegetables and fruits for human health. In the urban and periurbon areas, growing vegetables in pots and in homestead gardens will provide a rich nutrient source for daily fannily consumption as well as additional income to the growers. The export of horticultural crops to the neighgoring countries, through border trade and open market economy, will also promote the growers' income and poverty reduction. NGOs, INGOs, government and private sectors should make commitment in the improvement of horticultural production in terms of competitiveness in the international markets

Key Words : Fruits and vegetables, horticulture production, seed production, income, health

Introduction

Myanmar is located in South East Asia, lying between 10° and 28° N Latitudes and 92° and 101° E Longitudes. Myanmar has typically tropical and subtropical climate and there are three seasons: (1) the rainy season (mid-May to mid-October), (2) the dry cold season (mid-October to mid-February) and (3) summer season (mid-February to mid-May).The country is favored in land resources with a total land area of 67.66 mha. At present, the net sown area of the country is recorded as 12.61 mha (31.17 mac). Total crop sown area is about 20.41 million hectares (50.42 mac) having the crop production with cereals occupying over 48% of land area under cultivation due to open market economy for rice (Table 1). It was followed by pulses, oilseed crops covering each about 20 % of land area. The remaining food crops, industrial crops, medicinal and horticulture crops are about 15% of total cultivated land area. The horticulture crops occupy about 5% of the total cropping area of the country and it has more than 1.1 million hectares (0.58 mha for fruits and 0.74 mha for vegetables) in 2007-2008 (CSO, 2007).

Myanmar will continue to be agriculture base country in future because of possessing diverse agro-climatic conditions, abundant land and water resources. Therefore Myanmar agriculture plays an important role in contributing to the improvement of employment in rural areas in the whole food and non-food production chain.

1. VFRDC, Myanma Agriculture Service

Production of fruits and vegetables in Myanmar

Horticulture crops are widely grown in the whole country but mostly all of the quantities are for domestic consumption due to poor quality and constraints for exports in the past. From 1990s to the present the implementation of an open-trade economic policy substantially increased the volume of agriculture commodities including horticulture products to external trades (Figure 2). The largest horticulture production areas was found in Sagaing Division (19 %), followedy by Shan State (16%) and Ayeyarwaddy Region (12 %)(Table 2). It excluded naturally grown, wild crops and perennial type of vegetables and fruits such as drum stick, acacia and etc. The demand of horticulture product has increased in recent years due to increase of population and awareness of fruits and vegetables for human health. The significant amount of horticulture products (mango, watermelon, and musk melon etc) were exported through border trades to neighboring countries (Table 4). Myanma Agriculture Service introduced good agriculture practice (GAP) with the assistance of ASEAN cooperation. Therefore in the near future more horticulture product will be exported to external markets which may improve livelihood of the rural farmers.

In Myanmar more than a hundred kinds of vegetables and over sixty kinds of fruits are growing in different agro-ecological regions (MAS, 2005). Moreover, a large number of indigenous vegetables and fruits are well adapted to it. Because of differences in agro-ecological climates in different regions, growing season differs from one region to another. Consequently some vegetables are available in the market all the year round.

Vegetable crops consumed by Myanmar people can be classified into four groups: kitchen crops, seasonal vegetables, vegetables produced year-round basis, and vegetables grown naturally as wild species. The average annual growth rate of vegetables production is 5.4 percent and it is the highest among neighboring countries such as Thailand (1.0%), Bangladeshis (2.8%) and Pakistan (4.6%) (AVRDC, 2004).

Socio-economic aspects of horticulture crops

The horticulture production is essentially a farm business enterprise that benefits thousands of families in urban, peri-urban and rural communities in Myanmar. Growing vegetables provides self-employment to families who are engaged in all aspects of the business; raising nurseries beds, transplanting, crop management, harvesting, preparation for the market, and even selling. Most vegetable growers employ their family labor so as to reduce production cost and remain competitive in local markets. In peri-urban and available water resource areas, the main source of income is from vegetable production that has, to some extant, sustained their economy and livelihood. Small scale vegetable cultivation in Myanmar has made a contribution of income and poverty reduction.

In rural areas farmers generally collect wild varieties of vegetables from their farms and nearby jungles for home consumption and extra income by selling out in nearby markets. Effective seed implementation program is also needed for those areas. Vegetables and fruits grown in homestead and school gardens could be a valuable source of food for the family and the school, and it could

make an important nutritional contribution particularly to micronutrient intake. Home garden can be raised with spare family labor and the participation of women and children. It is therefore important for most households and virtually every school to devote more time to growing vegetables. A community garden near water source at the village is also a useful adjunct to the villagers' own backyard gardens. In cities, even the small piece of available land behind the house could, with the assistance of waste water, yield a valuable supply of vegetables all year round. Even people living in flats can grow certain varieties in pots kept on their verandas. Those types of producing vegetables support not only for daily family food consumption, saving daily household expenditure but also additional income.

Cost-benefit ratio of major vegetables production

Fruit and vegetable production is usually profitable and perishable compared to stable crops. Their product has high value added income generation potential and their production is attractive especially for small scale farmers. The cost and benefit of major vegetables and rice for commercial basis collected for the year 2007 are abstracted in the table 3. It is also observed that 50-60% of the total production cost has been invested for vegetable inputs like seeds, manure, fertilizers, insecticides, farm manure, plastic nets, bamboo sticks and other material costs. But some vegetable production has lower advantages than stable rice when labor and input are the limiting factors. Mostly small-scale farmers are facing difficulties with high cost of inputs such as seeds, fertilizers and pesticides and uncertainty of market for their products. This makes some farmers use open pollinated varieties and traditional landraces.

Fruits and vegetables consumption in Myanmar

Vegetables and fruits are essential for daily consumption in Myanmar. They are the most important sources of vitamins, macro- and micro-nutrients for the country people. In recent years, vegetables have gained great popularity among local people for health. It was estimated that consumption of vegetables in Myanmar may roughly be 200 g per day per head which was based on current productivity of vegetable and fruits. It was less than the WHO/FAO recommended rate which is 400 gm per day per head. Therefore all-out efforts need to strengthen to boost the production and productivity of horticulture crops in Myanmar. Moreover, consumption rate of individuals may depend on food availability and their purchasing power. Normally seasonal vegetables are cheaper in price at their peak harvest season so that consumers generally have more vegetables than other season.

Current sustainable horticulture activities

Many small scale farmers are engaging in this sector. Keeping in view of importance of horticulture in both livelihood security and economic support it is necessary to ensure sustainable horticulture production.

One of the important programs is enhancing farm family income (poverty alleviation) and nutrition through vegetable production and/or seed production of indigenous vegetables. Increasing vegetable and seed production will help enhance community food security by diversifying diets and sources of income. In the production of horticulture crops, farmers are using good horticultural practices in Myanmar under the framework of ASEAN cooperation. Promotion of the use of good agricultural practice requires wider education and transfer of the techniques to be taken care by both private and public sectors.

The organic vegetable production has also potential since Myanmar has large virgin and waste land across the country. However , there have been a very few efforts in this sector. It should be focused on farm-level participatory research, technology transfer, pesticide safety, integrated pest management and sustainable production systems.

Table 1. Crop sown area in Myanmar (2007-08)

	Crop group	Sown area ('000 ha)	Percentage (%)
1.	Cereals	7202	48.0
2.	- Paddy	6421	40.9
3.	- Maize	251	1.6
4.	- Others	530	5.5
5.	Peas & beans	3197	20.4
6.	Oil seed	2635	16.8
7.	Culinary	533	3.4
8.	Industrial	701	4.5
9.	Plantation	603	3.8
10.	Others& Horti: Crops	830	5.3
	Total	**15, 701**	**100**

Source : Agriculture at a Glance, MOAI (2007-2008)

Table 2. Distribution of horticulture sowing areas in different states and divisions (2007-08)

S.N	States and Divisions	Area (ha)	Percents
1	Kachin State	10080	4%
2	Kayar State	50400	2%
3	Kayin State	25200	1%
4	Sagaing Division	478800	19%
5	Chin State	75600	3 %
6	Tanintharyi Division	25200	1 %
7	Bago Division	252000	10 %
8	Magwe Division	252000	10%
9	Mandalay Division	226800	9 %
10	Mon State	75600	3 %
11	Rakhine State	151200	6 %
12	Yangon Division	75600	3%
13	Shan State	403200	16 %
14	Ayeyarwaddy Division	302400	12 %
	Total	**2494800**	**100%**

Source : Settlement and Land Records Department, MOAI (2007-2008)

Table 3. Cost of production and profit of some major vegetables

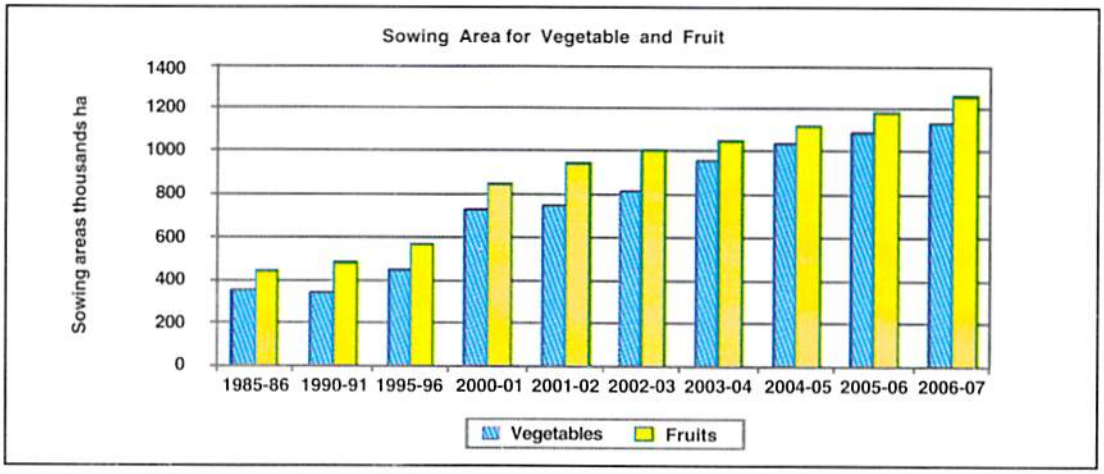
Sr.	Crop	Cost/acre (Kt)	Income/acre (Kt)	Profit (Kt)	Cost-benefit ratio
1	Lettuce	632,000	900,000	268,000	1:1.42
2	Cabbage	818,000	1125,000	306,900	1:1.38
3	Cauliflower	869,100	1255,000	355,900	1:1.41
4	Tomato	161,570	1,800,000	184,300	1:1.11
5	Onion	664,200	1,500,000	835,800	1:2.26
6	Garlic	688,300	1,000,000	311,700	1:1.45
7	Chilli (dry)	275,800	690,000	414,200	1:2.50
8	Potato (rain)	607,300	810,000	202,700	1:1.33
9	Potato (winter)	640,100	879,120	239,020	1:1.37
10	Yard long bean	584,800	744,000	159,200	1:1.27
11	Lady's finger	372,300	464,000	91,700	1:1.25

Source : Horticulture Division, MAS (2008)

Table 4. Export of major fruits in 2008 – 09 and 2009-10

Crops	2008-2009		2009-2010	
	Production(MT)	Income(M$)	Production(MT)	Income(M$)
Mango	21760	6.62	44360	11.935
Water melon	150365	19.165	152468	15.739
Musk melon	28421	5.867	27357	4.23
Total		**31.652**		**31.904**

Source : MFVP



Conclusion

Horticulture production in Myanmar needs to be improved in terms of quantity and quality for domestic and international markets. Processing of surpluses, the development of pre-and post-harvest handling, and marketing will be major fields of interest in the future. There are many favorable areas for vegetable seed production of tropical and temperate vegetable. Therefor evegetable seed production may become a very promising business to be emerged in near future. NGOs, INGOs and public-private partnership should make more commitment in the improvement of the existing horticulture production and marketing systems in Myanmar.

References

Annual report of Myanma Agriculture Service. 2007. Ministry of Agricultrual and Irrigation.

Central Statistical Organization. 2007. Myanma Agriculture Statistics. Ministry of National Planning and Economic Development, Yangon, Myanma.

Myanma Agricultural Services (MAS) Annual report. 2005. MAS, Myanmar .

Asian Vegetable Research and Development Center (AVRDC). 200 . ARC Training Report 2003. A compilation of research reports. p. 44.

DEMOGRAPHIC FACTORS CONTROLLING RETAIL SHOPS IN MEIKTILA TOWN

Moe Moe Khaing[1]

Abstract

Socio-economic condition of people is one of the major controlling factors to examine for the quality and spatial distribution of retail shop. Spatial distributions are related to the main factors such as locational distribution, types and size of building, ownership, distribution pattern and economic conditions. Demographic factors controlling retail shops are one of the most important indicators in the development process of a town. Data used in this paper were derived from office statistics and field surveys. Population is considered as one of the most important factors in the distribution of retail shops the intersection point of area.

Key Words : retail shop, population , demographic factors, spatial structure

Introduction

Retail is defined in various ways. This word comes from economic terms. There are many economic books and dictionaries to express the definition of retail and its related words such as retail shops, retailer, retailing, and etc. Among these books, the two popular dictionaries were selected to define the words, "retail" in this paper.

According to the Oxford Advanced Learner's Dictionary (Six edition, 2000) are including in it. Retail means the selling of goods to public, usually through shops / stores. Retailer means a person (or) business that sells goods to public. Retail shop means a place where you can buy goods (or) services.

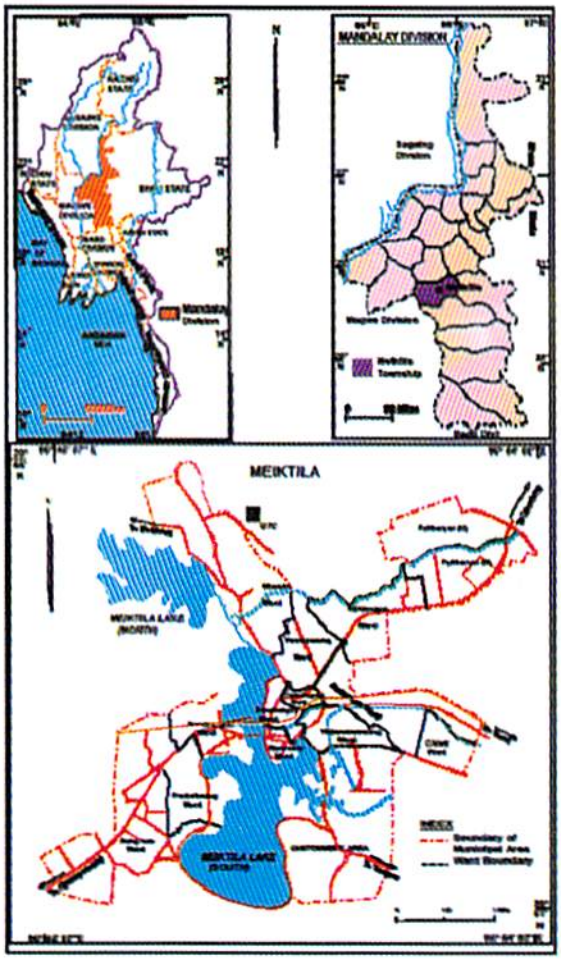
In the Webster's New World Dictionary, retail is to sell in small quantities directly to the ultimate consumer for personal (or) household consumption. Shop is a building (or) a room stocked with merchandize for sale. It is a small retail establishment or department in a large one offering a specified time of goods or services.

The study area

Meiktila is located in the southwest portion of Mandalay Division. It is one of the districts in Mandalay division. Physically, Mandalay division is mostly plains including Meiktila. It has a junction of five chief roads in Central Myanmar. Meiktila is connected with Thazi - Taunggyi Road, Pyawbwe - Naypyidaw - Yangon Road, Kyaukpadang Road, Myingyan Road and Mandalay Road. Therefore, it is a good transportation node in Myanmar. Because of above conditions, Meiktila has many economic hinterlands both whole sale and retail activities are developed in it. Besides, Meiktila, a place serves to exchange multi commodities from various parts of Myanmar

1. Assistant Lecturer, Department of Geography, Mohnyin Degree College, Kachin State, Myanmar

such as - agricultural and other products from Shan state, agricultural products in central areas and marine and agricultural products from lower Myanmar. The activities of retail shops are grown to support Meiktila and it's neighbouring towns such as Wundwin, Thazi, Pyawbwe, Yamethin, Mahlaing and Kyaukpadaung townships and many villages. In Meiktila, the activities of retails shops are mostly serving its environs and villages. These are mainly connected with Meiktila Central Market. (Map 1)



Map 1. Location of Meiktila Town

Methodology

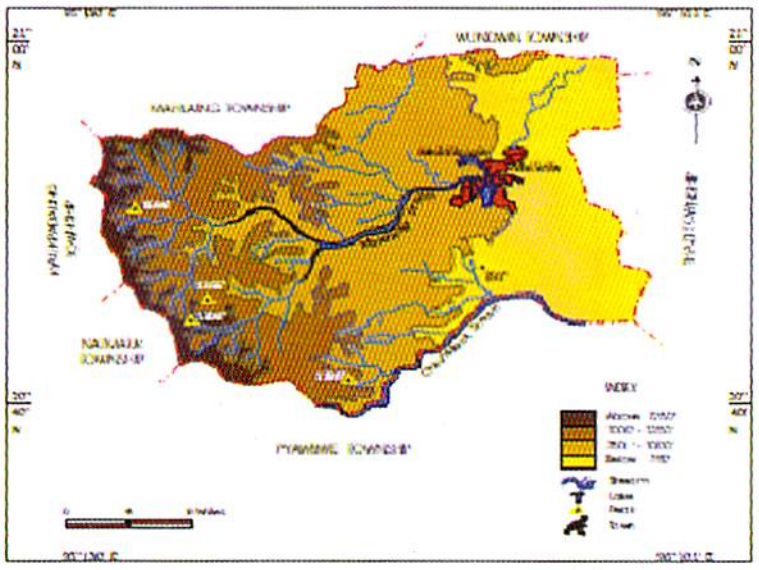
This paper is based partly on primary data and partly on the secondary data. The primary data is obtained from questionnaire, structured interviews and field observation. The questionnaires focus on shop owners or retailers to assess spatial distribution, selling and buying conditions of retail shops. Of the total number of 724 shop owners or retailers, 72 shops owners or retailers have been chosen for questionnaire survey. . Owing to incomplete responses, some have to be discarded and 45 shops owners or retailers remain for analysis. Simple statistical methods are used for comparison of the data.

Findings

Topography

Meiktila is located in Mandalay Division, Central Lowland of Myanmar. The relief of Meiktila also has rolling topography or undulating surface. Meiktila's topography mostly stands a little higher in the west, north and southwest and southeast. The ground surface is found to be relatively low level in the east and northeast. On average, this town lies at an elevation of 750 feet above sea level. (Map 2)

Besides, some parts of wards including study area such as Cantonment Area, Yadanamanaung ward, Myomalay ward, Zeashebyin ward, Pyitharyar wards (North and South), Thirimingalar ward lie on a level plain of 750 feet in height. Therefore, the study area is found to lie on the highest portion of the town. As locating in the highest portion, the study area lies on the surface with good drainage condition.



Map 2. Relief of Meiktila District

Population growth, population density and population distribution

In the study area, the population growth depends on the natural increase and net migration. In the earliest time, most of rural areas became insecure owing to insurgencies and thus, people moved from rural areas to nearby safer urban area. Accordingly, Meiktila became the focal point of immigrants. Table (1) shows some conditions of population growth in Meiktila. In 2004, the population of Meiktila was 89859 persons and in 2010, it increased to 92767 persons. During more than a half-decade period from 2004 to 2010, the growth of population was 2908 persons. In that period, the average rate of population growth was about 2.0 percent in Meiktila.

Table (1) shows comparison of population distribution and population density of wards in 2004 and 2010. In 2004, the average population density of Meiktila was 19924 persons per square mile and it increased to 20569 persons per square mile in 2010. According to good location, it generally increases with population density. The high population in some wards was due to their locations on the Yangon- Mandalay highway and close to central market of Meiktila.

In 2010, the high densities in some wards are due to their location near to highway vehiclesterminal and to CBD area and along the Yangon- Mandalay highway. Population density was partly to provide for retail shops of the study area. (Figure 1)

Table 1. Showing the comparison of population distribution and population density of wards in Meiktila (2004 and 2010)

No.	Ward	Number of Population	Number of Population	Population Density	
		2004	2010	2004	2010
1.	Aungsan *	11434	11697	13612	13925
2.	Paukchaung *	5040	4412	14400	12606
3.	Nandawgone *	7207	8392	20591	23977
4.	Myomalay +	2758	2710	25072	24636
5.	Zayashebyin +	5009	5451	29465	34065
6.	Yadanamanaung +	5987	5469	46054	42069
7.	Thirimingalar +	5252	4621	52520	46210
8.	Wunzin*	6495	9416	13819	20034
9.	Yanmyoaung +	12867	13078	26806	27246
10.	Kyidawgone +	4961	4970	10555	10149
11.	Aungzeyar +	9471	10544	29597	32950
12.	Chiset *	3139	2609	14268	11859
13.	Pyithayar (S) +	4439	4667	15854	16668
14.	Pyithayar (N) *	3796	4731	17255	21505
	Total	**89859**	**92767**	**19924**	**20569**

+ Some parts of the wards are included in the study area.

Source : Township Peace and Development Council, Meiktila Township, 2010

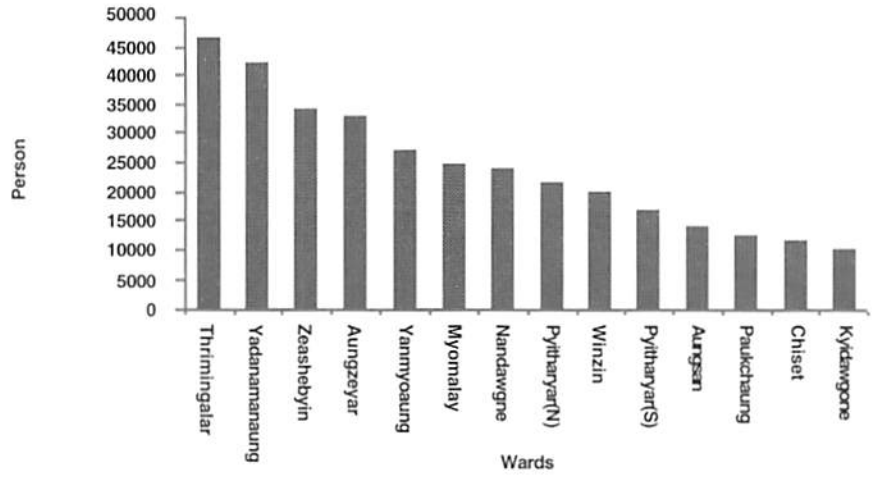


Figure 1. Population Density of Meiktila Town (2010)

Type and size of retail shops

Retail Shops can be divided into (7) main categories, in Meeiktila Town (Plate 1). They are:

(1) Food and Drink
(2) Grocery (Miscellaneous) shops
(3) Consumer goods shops
(4) Textile and Garment shops
(5) Construction Material shops
(6) Services
(7) Other shops

Type of retail shop building is one of the most important factors to study about the retail shops. It reflects to attract and interest for buyers and sellers. Based on their investments and economic development, most shop owners construct variously the type of building, ranging from bamboo hut, timber- brick (Semi brick / wooden) to brick types. In the study area, the general classification of the types of shop buildings are categorized into three levels such as low level (bamboo hut), medium level (timber and brick) and high level (brick).

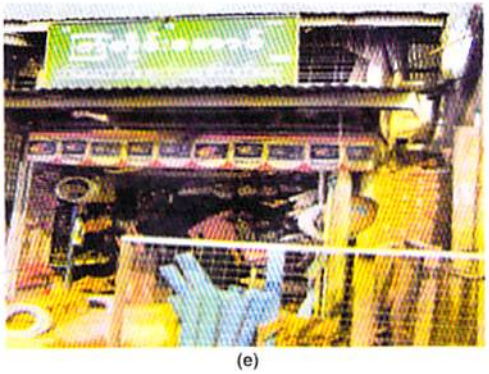
It shows the 45 sample types of retail shop buildings in the study area, of which 20 shops (45 percent of the total retail shop buildings) are bamboo huts as low level, 6 shops (13 percent) are with semi-brick type as medium level and 19 shops (42 percent) consist of brick type as high level.

(a)

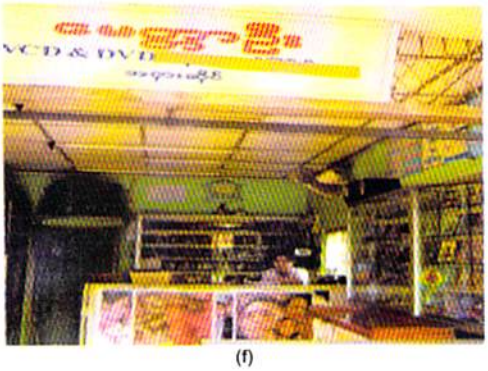
(b)

(c)

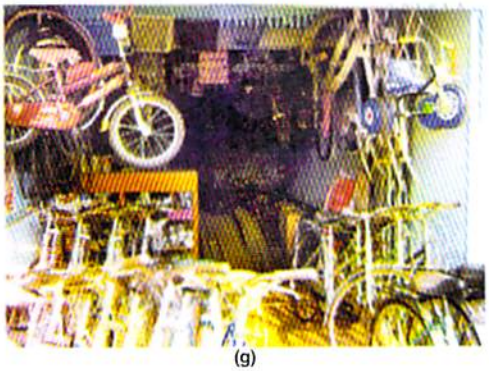
(d)



(e)



(f)



(g)

(a) Tea Shop Type (1)
(b) Grocery Shop Type (2)
(c) Consumer Goods Shop Type (3)
(d) Textile and Garment Shop Type (4)
(e) Construction Material Shop Type (5)
(f) Service Business Shop Type (6)
(g) Others Shop Type (7)

Plate 1. Types of retail shop in Meiktila Township

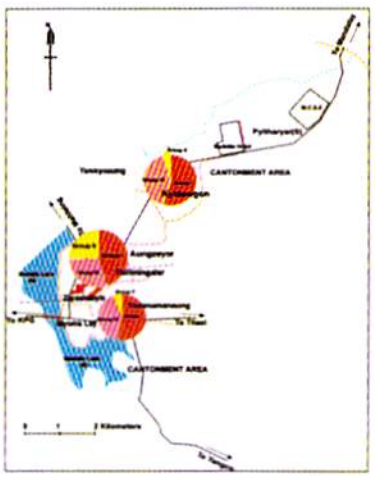
Source : Field survey

Spatial distribution of retail shops

Location means a place where something happens or exists and distribution, the way that something is shared over a study area. The locational distribution of retail shops vary in accordance with the locational pattern of wards. In the study area, retail shops are generally distributed at some parts of nine wards. In 2010, there are spatially distributed with 724 retail shops. Generally, there are 9 types of retail shops in the study area.

Based on their functions, these retail shops are classified into three groups. Group (1) is composed of Personal goods shops, Specialized services, Fast food shops and other shops which contain grocery shops, stores and various kinds of bakeries. Special service consists of beauty parlor, Video tape and VCD rental, TV game, photo studio, tailoring and electrical goods and their repair works. DaC includes teashops, food stalls (shops selling rice, noodle, Monhinkha, —) and restaurant. Bt means shops selling betel, cigarette and cheroots.

Group (2), called CMME, belongs to construction materials and machinery shops. Group (3) includes Ss, ScS, TrS and others. Ss contains shops such as computer printing and copier shops, stationary shops, medicine shops. ScS includes hostels, tuitions, and guesthouses. TrS consists of repair shops for motor cycles, bicycles, and cars and shops selling gasoline and diesel. Others include unidentifiable shops. (Map 3)



Map 3. Spatial distribution of retail shops in the study area (2010)

Transportation

Transportation is important for commodity flow and distribution of retail shops related to transport routes and road junctions as major retail shops establishments. Most of the retail shops are found along the major roads and road junctions. A number of bus lines and automobiles is also important for retail distribution because passengers travelling by buses and automobiles usually use retail shops along roadsides. There are land transportation routes but no air-way transportation route in Meiktila Township. There are two air-fields which are used for military training. These air-fields are located in Meiktila Township.

Meiktila Town is located at the intersection point of two Union Highways, namely Yangon Mandalay Union Highway I and Meiktila- Taynggyi-Kyaing Tung- Tachilek Union Highway IV in addition to being a hub of five other highways radiating from it. Thus Meiktila is a town with a very good communication system.

1. Yangon-Toungoo-Meiktila-Mandalay Union Highway (I) passes through Meiktila.
2. Meiktila-Thazi-Taunggyi-Kyaing Taung-Tachileik Union Highway IV begins from Meiktila.
3. Meiktila-Kyaukpadaung Highway connects Union Highways I and II.
4. Meiktila-Mahlaing-Taungtha-Myingyan Highway connects the Union Highway I and II.

Yangon- Toungoo-Meiktila-Mandalay Union Highway I passes through Meiktila and Wundwin townships in Meiktila District. This highway enters Meiktila Township with a total length of 24 miles 6 furlongs. Meiktila-Thazi-Taunggyi-Kyaing Taung-Tachileik Union Highway IV is 499 miles long. It passes through Meiktila and Thazi Township. The length of highway in Meiktila township is 6 miles and 2 furlongs long.

Meiktila-Kyaukpadaung Highway is 27 miles and 2 furlongs long. Meiktila Mahlaing-Taungtha Myingyan Highway is 70 miles long and passes through Meiktila and Mahlaing townships in Meiktila District. It is 10 miles and 4 furlongs long in Meiktila Township. Meiktila Township has the longest mileage of motor-road, a total of 71 miles and 5 furlongs forming about 43.64 % of the total mileage of motor-road in the district.

In addition, Yangon- Naypyitaw-Meiktila-Mandalay Union Highway is available in 2011. There are about 400 miles long and it passes through Meiktila Town. There are 18 bus lines which run to Meiktila Township from other places. There are 12 places which started the buslines running to Meiktila Township. These places include Taunggyi, Mandalay, Yatsauk, Taungoo, Taungthar, Chauk, Yangon, Mahlaing, Naypyitaw, Phyu, Loikaw and Yamethin.(Table 2 and 3) There are 12 bus lines which connect Meiktila Township to 7 places, namely Mandalay, Taunggyi, Naypyitaw, Kyaukpadaung, Myingyan, Wuntwin and Yangon.

Meiktila Township has the second longest railway line in the District. Thazi-Myingyan railway section in Meiktila Township is 16.6 miles long, forming about 12.02 % of the total railway in Meiktila District. When compared to its township area, it has 0.03 mile per square mile. Therefore, Meiktila Township has a good transportation and it in turn creates good distribution of retail establishments in Meiktila Township along some major roads.

Table 2. Bus line from other places to Meiktila (2009)

No.	Name of Bus line	Route
1	Shan Myittha	Taunggyi
2	Shan Myaylat	Taunggyi
3	Nagarni	Mandalay
4	Zartiman	Yatsauk
5	Keinnayar Shan	Taunggyi
6	Mya Yadana	Taungguu / Mandalay
7	Taung Tha	Taungthar
8	Shwe Nanthar	Chauk
9	Ka Pa Ya	Yangon
10	Hlaing Shwewa	Mahlaing
11	Shwe Chinthay	Taunggyi
12	Shwe Khitman	Naypyitaw
13	Shwe Pyisan	Phyu
14	Mahar	Yangon
15	Paunglaung	Naypyitaw
16	Tawwin	Naypyitaw
17	Tanmyanthu	Loikaw
18	Tilawa	Yamethin

Source : Township Administrative Office, Meiktila

Table 3. Bus line from Meiktila to other places (2009)

No.	Name of Bus line	Route
1	Bandula	Taunggyi/Mandalay/Naypyitaw
2	Shwe Nagar/Shan Ahyar/Chitkyiyay	Taunggyi/Mandalay/Kyaukpataung
3	Nawayat	Mandalay/Naypyitaw/ kyaukpataung
4	Myakanthar	Naypyitaw
5	Sakarwa	Kyaukpataung
6	Thirisan	Taunggyi
7	Myitta	Wantwin
8	Man Htilar	Mandalay
9	Man Yadana	Mandalay
10	Nyein Myanmar	Mandalay
11	ShweMandala	Yangon
12	Mandalar Min	Yangon

Source : Township Administrative Office, Meiktila TownshipCBD Area

Conclusion

Distribution of retail shops is related to the spatial distribution and population density of the study area, Meiktila Town. Statistical methods are related to apply in this study to examine the relationship between demographic factors and retail distribution.

References

Aung Kyaw and Naing Naing Aye. 2006. Spatial Structure of retail shops in Loikaw Town, Journal of the Myanmar Academy of Arts and Science, No.6, Vol. IV.

Htar Ei Chaw. 2004. Population Geography of Meiktila Township, Master (Thesis), Department of Geography, Meiktila University.

Mar Mar Swe. 2006. Oilseeds Cultivation of Meiktila, Master (Thesis), Department of Geography, Meiktila University.

Soe Sanda San. 2005. Assessment and Management on Water Resources of Meiktila Township, PhD Thesis, Department of Geography, Mandalay University.

Pyae Khaing Thu. 2010. Spatial Distribution of retail shops along the Yangon-Mandalay road in Meiktila , Master (Thesis), Department of Geography, Meiktila University.

LAND COVER AND LANDUSE CHANGES IN KYAUKSE TOWNSHIP

Bo Bo[1]

Abstract

The economic life of Myanmar is simply based on agriculture. According to the geographic factors, regions are different in their opportunity for the agricultural activities. In accordance with the developers, farmers and people have been endeavored for the development of agricultural activities since the early days. In many ways, irrigation is an effective one for the progress of agriculture and thus the different means of irrigation have been utilized in the dry areas including Kyaukse Township. To describe the potential strength of agriculture, a systematic research is carried out in this study area emphasizing on the changing patterns of agricultural land use.

Key Words : development, landuse, land cover, planning

The Study Area

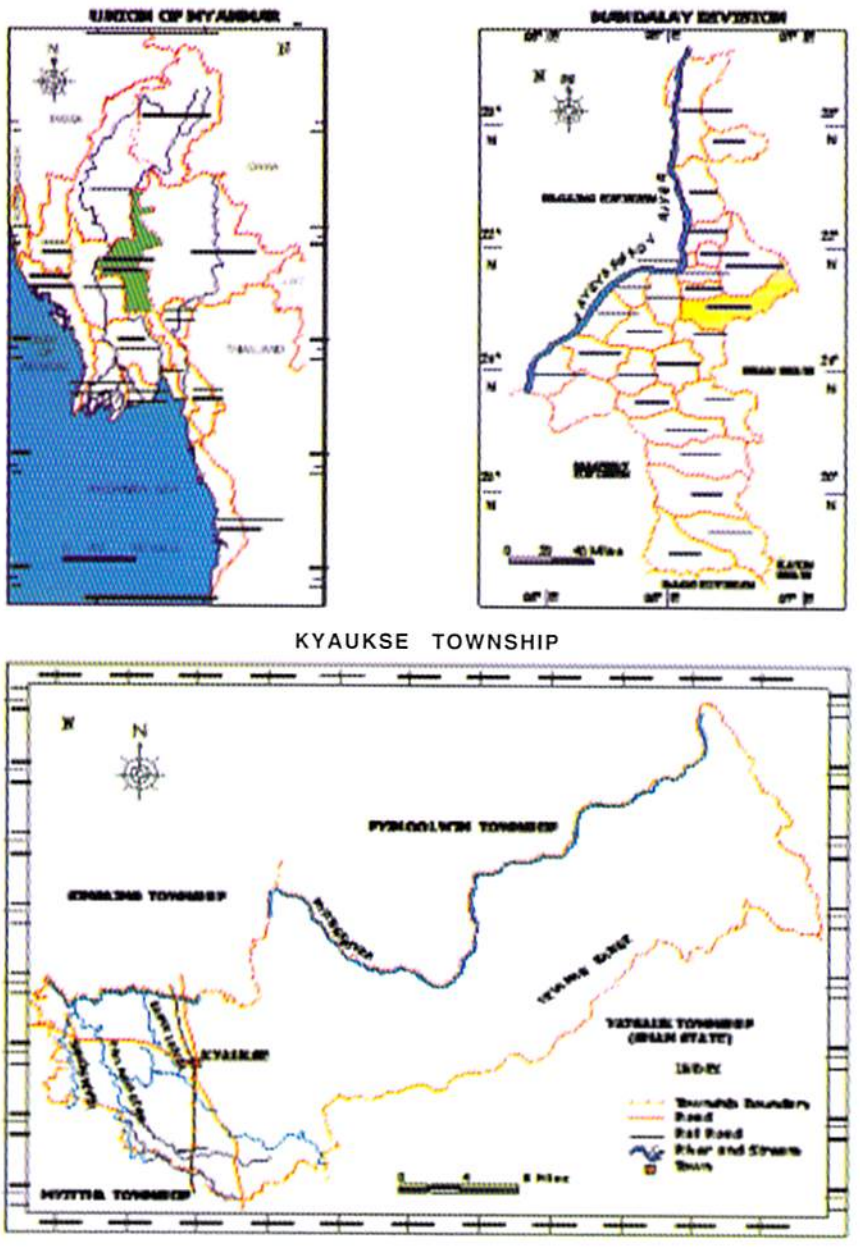
Kyaukse Township is situated in the Dry Zone of Central Myanmar, between north latitudes 21°26' N and 22°2' N and east longitudes 95°57' E and 96°58' E. This township is included in Kyaukse District of Mandalay Division. Kyaukse Township is bounded on the east by Pyin Oo Lwin Township of Mandalay Division and Yatsauk Township of Shan State, on the west by Tada-U Township, on the north by Singaing and Pyin Oo Lwin Townships, on the south by Myittha Township. Total boundary length is about (197.7) miles. The township has an area of 725.278 square miles (464,178 acres) which has an elongated shape.The township extends from northeast to southwest and generally it has a rectangular shape. Map (1)

Introduction

Land cover and land use are two key elements that describe the terrestrial environment in natural and human activity. Land cover may be of natural origin, such as forest, glaciers, rivers and other open water bodies, or bare soil or rock. However, it may also be created by land use, e.g. buildings, roads or water reservoirs. Hence, land cover refers to the composition of the features of the earth's surface. Land cover is characterized by the biophysical features of the terrestrial environment, typically based on a classification system consisting of discrete classes and formulated for a specific purpose.

Land use refers to the manner in which these biophysical assets are used by people. It is the employment of land cover and management strategy used on a specific land cover type by human agents, or land managers (Baulies and Szejwach 1997). The term land use may also be described the intent with which a particular land cover was formed. For example, a body of water may be a hydroelectric reservoir, a grass-covered area, a golf course, and bare patches inside a forest harvested areas.

1. Assistant Lecturer, Department of Geography, Mohnyin Degree College, Kachin State



Map 1. Location of Kyaukse Township

Methodology

To analyze the changing patterns of agricultural land use in this township, the required data are collected for two periods: 1988 and 2009. Because the satellite land cover maps are available for 1988 and 2009, hence it can be applied just for analyzing the changing pattern of land cover during 20-years period only.

The analysis is made according to the flow chart as shown in Figure (1). The land use pattern is mainly divided into cultivated and uncultivated lands. Detailed study is worked out by sub-dividing the land use patterns in irrigated and non-irrigated lands. Moreover, the changing patterns of agricultural land use are approached not only spatially but temporally with seasonal cropping patterns.

This study is intended to compare the relationship between economic activities and social conditions within Kyaukse Township. Qualitative and quantitative methods are used to express the economic and social development. The general condition of socio-economic feature of the study area is investigated by field observation and other data collection methods.

Secondary data and primary data are collected in the study area. Secondary data were received from many offices such as Township Peace and Development Council, Settlement and Land Records Department, Immigration Department, Fishery Department and Department of Agriculture etc. Primary data were obtained from field surveys, and questionnaires surveys. To seek information from acquaintances convenience samples are set up as samples. Interview and questionnaires 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 persons 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.

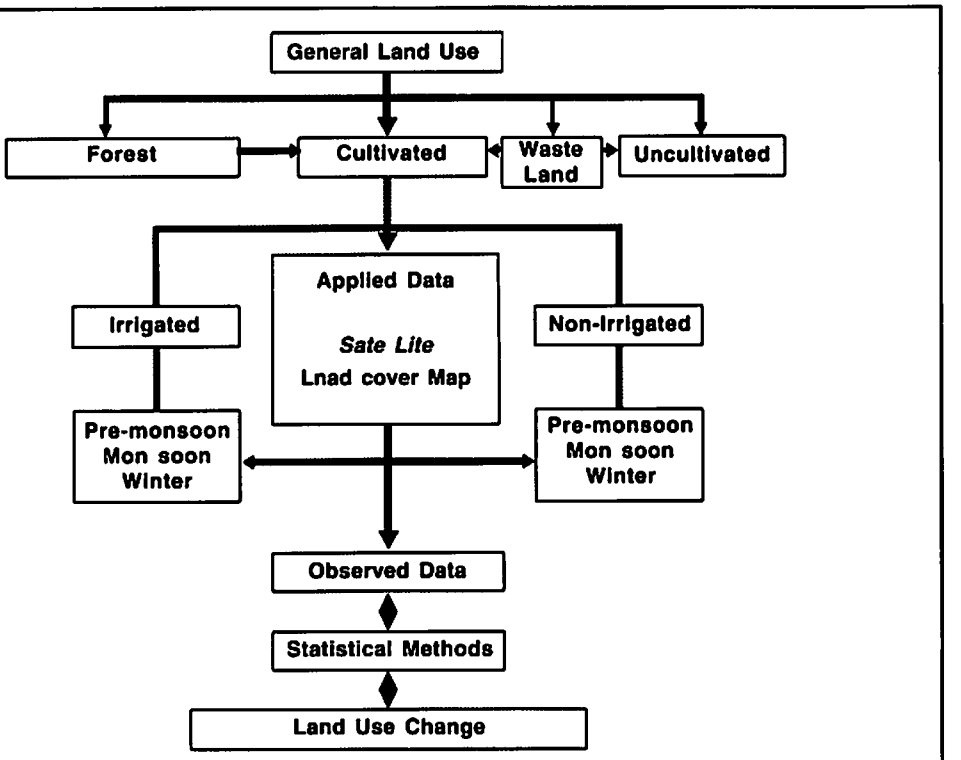


Figure 1. Flow Chart

Findings

General landuse

Official data of the government office used to classifies the various landuses into 4 classes as

1. Agricultural lands
2. Forest lands
3. Cultivable virgin lands and
4. Non cultivable lands

Agricultural lands

According to the data there are 113,166 acres of agriculture lands in Kyaukse township in 2009. The area of these agricultural lands forms about 24.38% of total township area. In Kyaukse township most of the agricultural lands are used primarily for cultivation of paddy, ya crops and garden crops. Paddy is chiefly cultivated in Le lands while ya crops and garden crops are grown in ya lands and garden lands. In 2009 there are 65,686 acres of le lands, 46,239 acres of ya lands and 1,241 acres of garden lands in Kyaukse township. The areas of these lands constitute about 14.05%, 9.96% and 0.27% of the total township area.However, as there was an irrigation network which has been constructed since the period of Pagan Dynasty, double cropping can be practiced in le lands and it provides surplus fond for the region.

The forest land area demarcated and administered by Forest Department since the colonial period. Due to forest and environments conservation policies of this department the authorized forest area has never changed and land use changes in forest areas due to population pressure and profitable agricultural production are limited as illegal actions. According to the data there are 263053 acres of forest area (56.68% of total area) in Kyaukse township. These forest areas include 255972 acres of reserved forests and 7111 acres of unreserved forests. The unreserved forests area is now recognized as the cultivable virgin lands by Land Record Department.

The uncultivable lands include urban and village lands, transportation lands, pasture lands and under water lands. In 2009, the area of uncultivable lands is 87929 acres and it forms about 18.94% of total township area. Although the proportion of the uncultivated area is small in total area of Kyaukse township most of the socio-economic activities are performed in these lands and it directly influence upon the socio-economy of the township. Therefore, it can be deduced that the investments in the development of uncultivated lands can bring about the socio-economic development of Kyaukse township under the systematic landuse planning and implementation. (Table 1 and Figure 2)

Table 1. General land use of Kyaukse Township (1988 - 2009)

No.	Year	Agricultural Land (in acre)	Forest Land	Uncultivated Lands
1	1988	108707	263083	92388
2	2005	112732	263083	88363
3	2009	113166	263083	87929

Source: Land Records Department, Kyaukse Township.

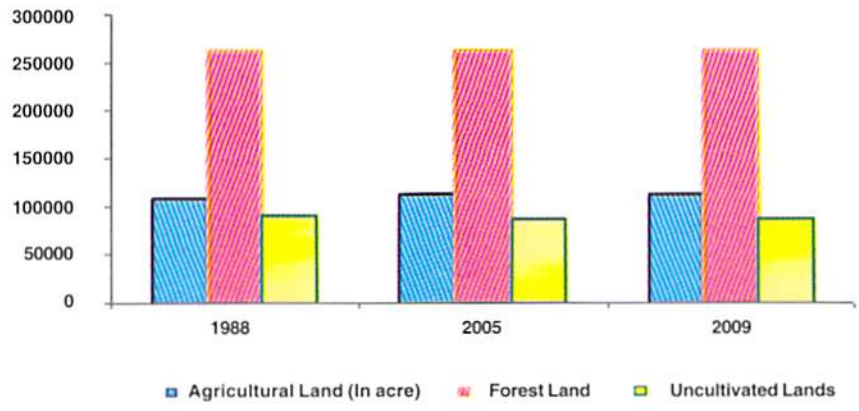


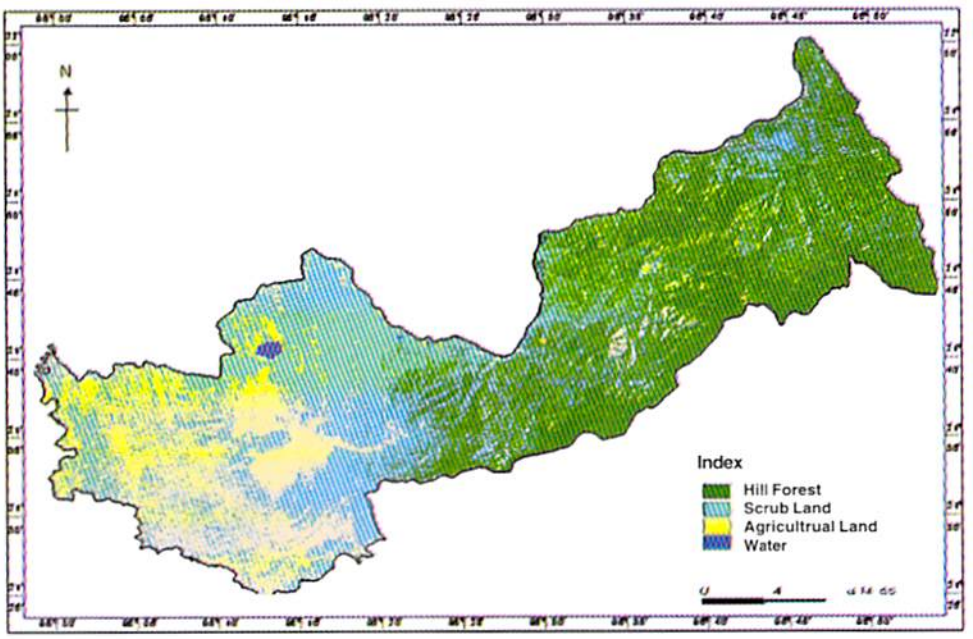
Figure 2. General landuse of Kyaukse Township

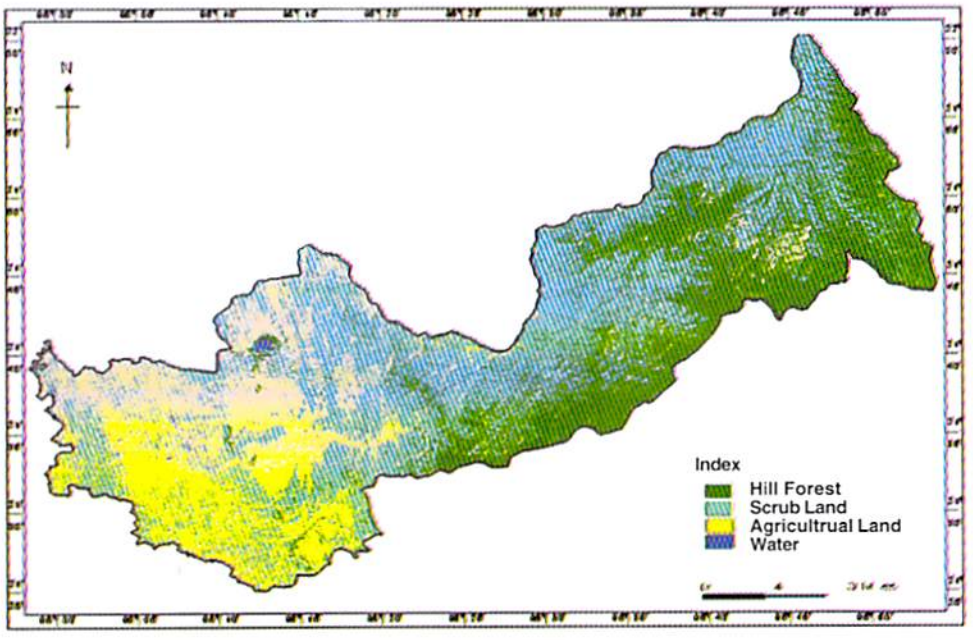
Changes from land cover to land use in Kyaukse Township (1988 and 2009)

For each parcel of land, individuals choose a type of use from which they expect to derive the most benefit considering a variety of things: their personal objectives and constraints: the given set of biophysical parameters, the institutional, cultural, and legal attributes of the land parcel; and the broader cultural and socio-economic environment. As characteristics vary in space and time so do land use choices, there will be in a spatial pattern of land use types. Since land use is the result of the interacting between society and the natural environment, knowledge of interaction is crucial for the study and improved understanding of human induced global changes and the institutional responses to them at all levels, from local to global. (J. Chilar & L. J. M Jasen, 2001).

For the study area the satellite images prepared by Remote Sensing and GIS Section, Forest Department are used. Based on these two images the changes from land cover to land use of Kyaukse Township for the two periods of 1988 and 2009 are analysed. Facts about these two images are shown in Map (1 and 2) and Table (2). According to the table it can be observed that four major types of land cover can be noted clearly and they are hill forest, scrub land, agricultural land and land under water body.

By observing the table it can be seen that the area covered by hill forest was greatly reduced in 2009 which amounted to (146,640) acres or (52.15 %) of the total hill forest area. It was mainly due to the changes from hill forest to scrub land or cultivated land. Actually, the land area under reserved or unreserved forest is not changed according to the data from Land Records Department, Kyaukse Township. In practise, the forested area identified by the Forest Department can never be altered to other type of land use (especially to the crop land). But, the local people wanted to cut-off the forest illegally for their family need or for fuel or for crop cultivation. Hence, types of deciduous forests are clearly different from 1988 to 2009.





Map 2 and 3 land cover of Kyaukse Township (1988 and 2008)

Source : RS and GIS Section, Planning and Statistics Division Forest Department, Yangon

Table 2. Land cover change between the years 1988 and 2008

Sr.	Class Name	Acres (1988)	Acres (2008)	Acres Changed	Percent (in increase or decrease)
1	Hill Forest	281144	134504	-146640	-52.15
2	Scrub Land	101315	167457	+66142	+65.28
3	Agriculture	88698	159962	+71264	+80.34
4	Water	3021	2255	-766	-25.35
	Total	**464178**	**464178**	-	-

Source : RS and GIS Section, Planning and Statistics Division, Forest Department, Yangon

On the other hand, lands under scrub land are also changed between these two periods and about (66,142) acres were increased in 2009 compared to 1988. In other words, about (65.28%) of scrub land were increased from its total of the year 1988. The increase of scrub land area is chiefly related to the process of deforestation on hill forest area. This change indicates some distinct pattern of land cover change in this area.

According to the table, it can be accepted that the area under agricultural land use was sharply increased from 1988 to 2009 and it measures (71,264) acres or (80.34%) over total cultivated area of the year 1988. It may be due to the reclamation of crop land from the cultivable wastes occurred in scrub land or hill forest. In contrast, the total area of land under water was decreased down to (2,255) acres and this amount is (766) acres less than the record of 1988. In other words, about (25.35%) of the area under water is decreased from its total of (3,021) acres in 1988. It may be due to the difference in time of photo taking and the second photo image is taken during someday of summer. In a brief sense, it can be said that the area received the situation of land cover change and that change influences the pattern of land use in this area.

General land use

To study the changing patterns of general and agricultural land use clearly, data from secondary sources are collected for two periods, i.e. 1988 and 2009. In Kyaukse Township, four major types of general land use are classified based on the data from Land Records Department. They are the land under forests, cultivated land, uncultivated land and wasteland. The forest land can be subdivided into reserved and unreserved ones. For both years the total forested area are not varied and it occupied about 53.15% of the geographical area of township. Due to the nature of Forest Department, total forest areas are always preserved as only one unit and they are not changed in the official data. However, the actual areas of forest are to some extent changeable for the invasion of agricultural land or residential land into forest areas. But types of forest have been changed during 17-year period, (i.e. from deciduous forest to scrub land). Figure (3) shows that the comparisons of general land use pattern in Kyaukse Township for 1988 and 2009.

Under the cultivated land use, the total area under various crops and the land which are left for at least one or two growing seasons are included. In the study area, there is not a single acre of fallow land. Under cultivated area, about (107,807) acres or (23.22%) of total geographical area and about (112,732) acres or (24.29%) of total area were found in 1988 and 2009, respectively. According to this figure, the total cultivated area has been increased within 17-year period. But, due to the presence of Yeyaman Range and forests, its increase is not much high.

Under the category of uncultivated land, there are various types of land use such as the land for mining; the land under factories; the land use for irrigation, lake, canals, etc; institutional land use; the land use for roads and rail lines, the land under rocks, boulders; unclassified land, residential land use; etc. Uncultivated lands are found in the study area and it accounts for (98,584) acres or (21.23%) of the total area in 1988 and for (88,363) acres or (19.03%) of the total area in 2009. Due to the changes of government policy, the land use for factories and residents has been increased within 17 years. During 1988 and 2009, total uncultivated land is decreased. This may be the reason of the introduction of state-owned factories around Kyaukse town. For both study periods, it is observed that there is a great benefit for agricultural land use. That is the decrease in wasteland from 1988 to 2009. Most of the wasteland might have been changed into cultivated land after 17-year span. In 1988 and 2009, the wasteland accounted for (11,072) acres or (2.38%) and (7,111) acres or (1.53%) of the total geographical area, respectively.

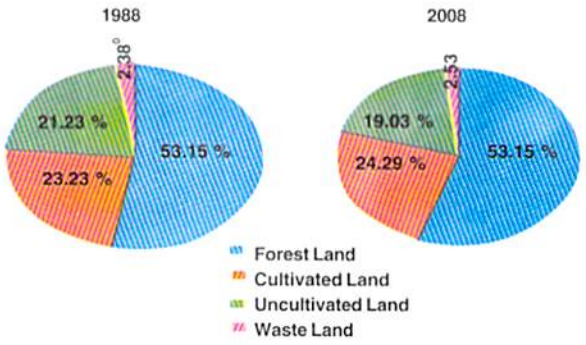


Figure 3. Comparison of general landuse pattern in Kyaukse Township (1988 & 2008)

Source : Based on Data from Lnad Record Department, Kyaukse.

Conclusion

There is a close relationship between land cover changes and land use of Kuaukse Township. Since, the regional development policy tried to create an industrial zone in Kyaukse Area, some agricultural lands are transformed into industrial lands. Case study on agricultural use and industrial use showed the spatial and temporal variation of landuse in Kyaukse Township.

References

Cherry Win. 2001. "Spatial-temporal Pattern of Paddy Cultivation in Kyaukse District", M. Res (thesis), Department of Geography , Mandalay University.

Tin Moe. 2008. "Spatial Analysis of Agricultural Productivity by Irrigation in Kyaukse Township", PhD (thesis), Department of Geography, Mandalay University.

Thuzar Win Shwe. 2009. Geographical Analysis on "Changing Patterns of Agricultural Landuse in Kyaukse Township", PhD (thesis), Department of Geography, Mandalay University

Yu Yu Swe (2000) "Agricultural Resources of Kyaukse Township" ,M.A (thesis), Department of Geography in Mandalay Universiy.

Index

A

B

C

D

E

F

G

H

I

L

M

O

P

R

S

T

U

V

W

Yezin Agricultural University, Yezin - Naypyitaw, MYANMAR and
Center for Southeast Asian Studies, Kyoto University, JAPAN
ISBN: 978-4-9016689-0-3