Successful Cases on Sustainable Rice Paddy Farming Practices and Wetland Conservation in Asia

—based on “the International Workshop on Rice Paddy and Wetland Conservation: Best Practices in Asia” held in Takashima, Japan on August 6-7, 2010—

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Foreword

This volume contains the proceedings from the International Workshop on Rice Paddy and Wetland Conservation: Best Practices in Asia held in Takashima, Japan on August 6-7, 2010. Organized by the Ministry of the Environment, Japan together with the Ramsar Regional Centre East Asia, Wetlands International Japan, the Ramsar Centre Japan, and Takashima City, it provided a regional platform for wetland scientists, managers and the broader wetland community to come together and discuss the sustainability of rice paddy farming practices and wetland conservation.

In many ways, the rice paddy itself can be considered a form of wetland. The Ramsar Convention recognizes the potential role of such "man-made" wetlands in regional wetland conservation, especially in supporting migratory bird species. The supplemental benefit of well-managed rice paddy can be seen in the large numbers of birds utilizing these habitats along flyways. Given the widespread decrease of bird populations in Asia and ongoing impacts to wetlands, the role of rice paddy may increasingly be critical to species survival. Whilst the many drivers of habitat loss and degradation (including agriculture) need to be addressed regionally, the potential for habitat restoration and approaches which better integrate wetland conservation with agricultural production also need to be considered.

The concept of "multi-functionality" lies behind many of the presentations from this Workshop. Often referred to as "eco-agriculture" or "agri-ecology", the recognition and protection of ecological components and processes within the agriculture landscape is a core principle in what many regard as a more sustainable way of production. For wetlands, this approach requires the conservation of not only natural wetland systems across the farming landscape but also the adoption of land uses and practices which assist in the maintenance of these wetlands. In rice production systems this affects the selection of rice varieties, how rice is grown and harvested, the sources of farm water and the hydro-biological connectivity of the farm to surrounding wetlands. It may result in less or no pesticide use, winter flooding of rice fields, crop types which encourage native species, and farming infrastructure which favours the movement of animals and plants between farms and adjacent wetlands. Many other novel advances in multi-functionality are occurring within agricultural systems which do not affect yields, and these too should be encouraged.

Importantly, the benefits from well-managed rice paddy extend outside of biodiversity conservation to groundwater recharge, climate moderation, flood and erosion control, landslide prevention, provision of plant and/or animal food resources and medicinal plants. This has been explicitly recognized by the Ramsar Convention through the adoption of Resolution X.31 "Enhancing biodiversity in rice paddies as wetland systems". Significantly, it is many of these "ecosystem services" which may be the most influential in achieving better recognition of the values of traditional rice paddy cultivation, and in doing so, help to drive regional wetland conservation. A better understanding of such services is needed in Asia, especially their valuation as part of decision support tools in landscape management. In particular, the cultural values associated with integrated rice paddy-wetland systems require further research.

Papers on this theme are presented by authors drawn from across Asia representing various different organizations in the public, private and community sectors. From the role of rice paddy in climate change mitigation to integrated methods of agricultural intensification, and from the policy drivers for achieving change to the best practices on-ground – these proceedings provide a contemporary assessment of the challenges and opportunities facing the region in balancing food production with nature conservation.

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Sustainable Rice Paddy Management for the CBD 2020 Target

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1. Introduction

At the COP10 of the CBD (Convention on Biological Diversity) held in October 2010 in Nagoya, the 2010 Target adopted at the COP 6 in 2002, will be reviewed and a Revised Target will be adopted. Since the GBO-3 (the third edition of Global Biodiversity Outlook), produced by the CBD and published in May 2010 confirmed the failure of the 2010 Target, the revised targets have been developed and proposed with detailed indicators and measures necessary for the better attainment and implementation of goals for conservation of biodiversity and provision of ecosystem services[*1].

The targets and indicators to be adopted at the COP10 are closely related with sustainable rice paddy farming practices and their management. Thus it will be a great opportunity and contribution to both the CBD and the Ramsar Convention that a study program on rice paddy is conducted in collaboration with NGOs in the Asian Region. Such a study may include researches on status of rice paddy farming, trends in rice paddy production, pollution into and from rice paddy, traditional rice paddy management, wildlife which live on rice paddy and the ecological functions of rice paddy, as well as agricultural policy and laws relevant to rice paddy.

2. Rice Paddy CEPA

Among the Targets included in the proposed Revised Target, Target 1 refers to the Communication, Education and Public Awareness (CEPA), and requires such basic actions as public awareness campaigns, national baseline surveys and national CEPA strategies. CEPA is a fundamental tool that should be used at national, regional and local levels, involving all stakeholders including children. Among a lot of Multilateral Environmental Agreements containing provisions on education and public awareness, CEPA has been promoted mainly by CBD and the Ramsar Convention for the effective implementation of their provisions and relevant national laws in each Contracting Party[*2]. As maintenance of biodiversity is a

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*1 CBD, Draft Decisions for the Tenth Meeting of the Conference of the Parties to the Convention on Biological Diversity (UNEP/CBD/COP/10/1/Add.2/Rev.1) p.23-25.

*2 CEPA Programs have been developed and launched mainly by the Ramsar Resolutions VI.19, VII.9 and VIII.31, and fundamental base of human activities, including rice paddy farming, the actual status of biodiversity needs to be understood by all stakeholders including the general public. This need may well be supported by CEPA, especially by the Rice Paddy CEPA Program.

Regarding participation of people in the decision making and management process, the Åarhus Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters, adopted in 1998 and entered into forth in 2001, is one of the leading legal instruments. For participation of local people, the Ramsar Convention has also been playing an important role. In particular, it adopted the Guidelines for Establishing and Strengthening Local Communities' and Indigenous People's Participation in the Management of Wetlands[*3]. The Guidelines set out detailed items and indicators for desirable actions, systems and procedures for participation, which will be useful for effective participation by local peoples who support rice paddy ecosystem. In addition, the Ramsar Convention adopted a resolution on participatory environmental management (PEM) as a tool for management and wise use of wetlands, and its annex set out detailed guidelines for PEM[*4].

3. Sustainable Rice Paddy Management

Target 2 and Target 3 relate to economic aspects and they call attention on such items as subsidy, transparent and comprehensive inventories, subsidy removal or reform, as well as effective phase out, positive incentive measures for the conservation and sustainable use of biodiversity. And Target 4 and Target 7 cover the issue of the ecological limits both from ecological capacity to produce resources and that capacity to purify pollution, and require preventing over use, to reduce total demand, and to reduce negative agricultural impacts by chemical compounds on biodiversity.

For Targets 2 and 3, in Nagoya COP10, such economic aspects are treated under the theme of the Economics of Ecosystems and Biodiversity (TEEB), and TEEB is one of the key concerns in rice paddy management. For the other two Targets, some rice paddy production methods actually cause not only contaminated food problems but also chemical and nutrient pollution on the ecosystem that supports the agricultural activity.

These four Targets relate to a general concept of Sustainable Development, Sustainable Utilization, or Wise Use under the Ramsar Convention. To properly understand the sustainable utilization concept, one needs to be reminded of the Revised Definition of Wise

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CBD Decisions VI/19, VII/24 and VIII/6.

*3 Resolution VII.8 (1999).

*4 Resolution VIII.36 (2002).

Use by the Ramsar Convention, which states as "the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development" (RES IX.1A). It was changed from the old definition as follows "their sustainable utilization for the benefit of humankind in a way compatible with the maintenance of the natural properties of the ecosystem" (REC 3.3). The revised definition states clearly that any utilization activity is premised on proper conservation and maintenance of ecosystem or biodiversity, and it has an important implication on rice paddy management.

Other key instruments on sustainable utilization of biological resources are the Principles and Guidelines on Ecosystem Approach[*5]: and the Addis Ababa Principles and Guidelines on Sustainable Use of Biodiversity[*6]: In carrying out the rice paddy research activities, these instruments could provide very useful basic framework and items and processes to be taken into consideration.

In addition, a careful attention should be given to the Millennium Development Goals (MDGs), in particular, to the Goals 1 and 7[*7], for sustainable management of rice paddy.

4. Integrated Rice Paddy Management

Target 8 provides for general actions necessary for prevention of biodiversity loss, and Target 9 approaches from one of the causes of such loss, the introduction of invasive alien species. Since lots of rice paddy suffer such biodiversity loss and ecosystem dysfunction, as well as the introduction of alien species, it is necessary to analyze causes of biodiversity loss in rice paddy ecosystem and take effective control measures.

Target 13 looks at this from the agricultural perspective, and raises issues such as conservation of genetic diversity of crop and livestock diversity on farms, and actions necessary for adaptation to prepare for changing conditions, especially such as climate change, and then requires to collect and conserve those genetic diversity both in situ and ex situ. Target 15 relates to soils, and places an importance on ecosystem resilience and carbon storage. And Target 18 covers the cultural and social values, and calls attention on

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*5 Ecosystem Approach, Decision V/6, CBD; Ecosystem Approach: Further Conceptual Elaboration (UNEP/CBD/SBSTTA/5/11, 23 October 1999); Ecosystem Approach, Sustainable Use and Incentive Measures (UNEP/CBD/COP6/INF/24/Add.3, 4 March 2002).

*6 Annex II, Decision VII/12 Sustainable Use (Article 10).

*7 GOAL 1: Eradicate Extreme Poverty & Hunger
GOAL 7: Ensure Environmental Sustainability

the importance of local and daily life, including traditional Knowledge (TK) on rice paddy management.

These Targets require a wider consideration for sustainable management of biological resources. Since social, economic, cultural and biophysical environments are complementary, an integrated approach reflecting a broad perspective on biodiversity is required at the stage of a wider master plan at national, regional and local levels.

In this regard, the Akwé: Kon Guidelines[*8] is a remarkable attainment for cultural consideration. Another attainment is found in a process of the strategic environmental assessment (SEA) procedures. CBD has developed the guidelines for incorporating biodiversity-related issues into environmental impact assessment (EIA) legislation and/or SEA[*9]. The Biodiversity EIA Guidelines adopted at CBD COP8 set out detailed actions and procedures for integrated assessment of development activities[*10], and may be useful when considering sustainable rice paddy management.

Currently, an integrated management is required by many international instruments including the Agenda 21 (Chapter 17), the United Nations Environment Programme (UNEP) Global Programme of Action for the Protection of the Marine Environment from Land-based Activities[*11], the Ramsar Convention, CBD, the World Heritage Convention and others. In particular, the Principles and Guidelines for Incorporating Wetland Issues into Integrated Coastal Zone Management adopted under the Ramsar Convention contains basic understandings, detailed items to be considered and necessary procedures[*12], and it will be a useful reference for sustainable rice paddy management.

Such an integrated approach may avoid confronting or competitive activities and the

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*8 Akwé: Kon Voluntary Guidelines for the Conduct of Cultural, Environmental and Social Impact Assessments regarding Developments Proposed to Take Place on, or which are Likely to Impact on, Sacred Sites and on Lands and Waters Traditionally Occupied or used by Indigenous and Local Communities (CBD Dec. VII/16 F, Annex).

*9 Indicators and Environmental Impact Assessment (UNEP/CBD/SBSTTA/7/13); Draft Guidelines for Incorporating Biodiversity-Related Issues into Environmental Impact Assessment Legislation and/or Process and in Strategic Environmental Assessment, Annex to Recommendations VII/10. Further Development of Guidelines for Incorporating Biodiversity-Related Issues into Environmental Impact Assessment Legislation and/or Process and in Strategic Environmental Assessment (UNEP/CBD/COP/6/4); Annex I and II to the Note by the Executive Secretary on Voluntary Guidelines on Biodiversity-inclusive Impact Assessment (UNEP/CBD/COP/8/27/Add.2).

*10 Voluntary Guidelines on Biodiversity-inclusive Impact Assessment (Annex I, CBD Dec. VIII/28).

*11 UNEP(OCA)/LBA/IG.2/7.

*12 Appendix 1, Resolution VIII.4, Wetland issues in Integrated Coastal Zone Management (ICZM).

duplication of management efforts, whilst encouraging other complementary activities which further promote efficient and mutually supportive practices in rice paddy management. However, there are barriers that hinder the effective implementation of such new processes, including bureaucratic inertia, opposition to changes, opposition from multiple private economic interests, lack of adequate political will to start the process, lack or minimal financial resources, complexity of the legislative issues in defining target areas, and a lack of understanding between natural scientists and land use planners. Supportive actions and procedures which may break down these barriers into the management process are needed

The Rice Paddy Resolution and its History

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The Rice Paddy resolution has its beginnings in several meetings that have taken place in East and Southeast Asia over the last several years. The first mention of rice and wetlands, or more appropriately of agriculture and wetlands was in COP8 with resolution VIII-34. This resolution dealt principally with agriculture and wetland water resources. Three years later COP9 was held at Kampala in Uganda, about the same time Kabukurinuma became a Ramsar site. During this COP, "Asian Rice Paddies" was supported as a side event. In the following years, there was an increase in the information available on rice paddies with meetings being held in Japan and Korea in 2006 and 2007. This increased further in 2007 with the East Asia Wetland Forum discussing the Importance of Rice paddies in Changwon Korea. Also during this period (2006-2008) there were 10 meetings related to the development of organic rice farming in East Asia held by many NGO's in Japan and Korea. All of this was capped off by the acceptance of Resolution X-31 at COP10 in Changwon, South Korea.

X.31 Enhancing biodiversity in rice paddies as wetland systems

RECOGNIZING that rice is grown in at least 114 countries worldwide and, as the staple diet for over half the world's population, has contributed to about 20% of the total calorie supply in the world;

RECOGNIZING that rice paddies (flooded and irrigated fields in which rice is grown), a typical agricultural landscape for a significant proportion of world rice cultivation, have provided large areas of open water for centuries in regions with a variety of rice-growing cultures, and, in addition to producing rice, also provide other animal and/or plant food sources and medicinal plants, thus acting as wetland systems and helping to sustain livelihoods and human well-being in these regions;

FURTHER RECOGNIZING that aquatic biodiversity associated with rice paddies can make an important contribution to the nutrition, health and well-being of rural populations;

RECOGNIZING ALSO that in some particular regions, it is important that irrigated rice paddies remain connected to surrounding natural/semi-natural habitat, in particular to wetlands, for the sake of biodiversity.

While each of these meetings dealt with rice production, they did have different target aspects of rice or agricultural production, as it relates to wetlands in Resolution VIII-34. This resolution specifically deals with the impact of agriculture on wetlands and water resource management. Furthermore, it specifically identifies that the impact of farming on water and water management, due to the amount of land used for agricultural purposes, is intense. As well, due to the relation of people with their associated natural world, water influences how people function in that world, especially as it relates to wetlands.

This resolution began the impetus to understand the relationship between agriculture and its role in Asia, as symbolized by rice production. Korea and Japan took up the first call to determine the role of rice paddies in this light, with Uganda holding Ramsar COP9 at Kampala. This was accompanied by a side event in which rice paddies in Asia were highlighted, and the acceptance of Kabukurinuma as a Ramsar Site occurred. This was a significant event in that rice as a crop supports the majority of the cereal grains eaten produced and eaten globally with 500MT being farmed a year. In Asia, this accounts for about 20% of the total caloric consumption of each person. The focus for the side event showed that rice is produced in a variety of manners, and that it can be produced sustainably. Other activities involved in the side event identified the role of rice paddies as waterbird habitat, the restoration of biodiversity and its relation to the improvement in biodiversity associated with them.

Following the COP9 meeting in Kampala, the investigation into the role of rice in wetlands and its production, became more intense with research and meetings on the importance of rice paddies, joint surveys of NGO's (Korea and Japan), and symposia on rice paddy wetlands. These meetings brought up different aspects of rice paddy wetlands and their need for protection and conservation under the Ramsar Convention. In focusing on the different aspects of rice farming, the research delved into the impacts of conventional mechanical farming and traditional practices farming and they found that there was a strong correlation between traditional practices farming and biodiversity. This was further researched, and over time, produced a trend towards organic farming. This trend has been realized ever since the COP9 meeting, in a slow sequence, moving towards improved organic farming techniques.

Part of the movement towards traditional practices farming was the involvement of integrative farming. This practice involves the use of ducks as a form of pest control. The ducks are used as pest control during the growth phase of the rice, and then the ducks can use any rice that drops from the plant, as a source of food, when the paddy is not flooded. This process, was further adapted in Korea, with the establishment of the Biodiversity Management Program, where barley, wheat, or oats were left on the field for the migratory birds moving through the area around Junam Reservoir.

As part of this process, another practice that has recently been implemented, in the last decade in Japan and the last five years in Korea, is the winter flooding of rice paddies. This process, which has the rice paddies flooded for a period during the winter, is a means of maintaining the soil fertility, thereby reducing the dependency upon fertilizers as a method of increasing rice paddy productivity.

The Role of Non-Government Organizations

Following the developments of COP9 in Kampala, non-government organizations became involved and spearheaded, in some ways, the movement towards organic rice farming. The involvement of the NGO's was a boon to the increased development of the Rice Paddy Resolution. NGO's in Korea have fostered the continued evaluation of rice paddy wetlands, including the monitoring and analyses of the collected data.

Both Korean and Japanese NGO's worked hard at providing data supporting the ideas that rice paddies which were farmed traditionally and organically produced greater levels of biodiversity than mechanically farmed rice paddies. Work in Bonghwa and other areas in Korea, has provided substantive data, which shows with organic farming the agricultural practices are far more environmentally friendly than mechanical agriculture. As well, they have found that while productivity shows an initial decrease, due to the reduction in overall plants grown, the individual plants are healthier and correspondingly produce more seeds per head, which are also more robust. This work was corroborated by work done in Japan, which also supported an increase in organic farming relative to the amount of mechanical agriculture.

To disseminate this information, the NGO's took advantage of the growing interest in organic farming and delivered a variety of seminars, workshops, and symposia on the development of organic farming and traditional rice farming over mechanized agriculture. These workshops, held in Korea, Japan and other Asian nations increased the visibility of organized rice culture, and furthered the development of both traditional and organic rice farming. The meetings all showed that there is a benefit to growing rice traditionally or via organic methods.

This information was then distributed via the news and other more traditional forms of news releases (conferences), where the NGO's have shown the results of their work. Politicians, who saw that they could promote an increasingly environmental friendly product to the population, then took this up.

To date there is only one major drawback to the process. This drawback is currently the focus of future work and more research and development. How is it possible to increase the yield of the organic crop without decreasing the environmental value that has been re-established in the organic crop? That is the cost of the product is currently limiting its practicality and its utilization.

Currently the cost per unit production for organically farmed rice is very high. To offset this cost the farmers are forced to increase the cost of the product. In times of economic hardship, people will choose their bankbooks over the environment. Therefore, we are left with defining methods, and approaches that can improve the cost to production ratio for the crop. How can this be achieved?

Future Directions for Rice Paddy Research and Conservation in Korea

The future direction for rice paddies and their conservation, at least in Korea, involves the development of methods that work towards increasing the production level of the crop while retaining the ecological characteristics of the rice paddies with respect to biodiversity and ecological integrity.

Research is being performed that may lead to the expansion of these components of rice paddy cultivation. The primary focus of this research at present is focusing on organic, or green, rice paddy cultivation. In Korea, there are local initiatives that promote the development of organic rice cultivation, which are supported to some extent by local politicians. If research in this area is promoted and fostered there is every chance that organically grown rice with increased productivity and supporting a decrease in cost per production should be a possibility.

Farmers are working towards defining sustainability through the enhancement and expansion of organic farming. This approach, while not necessarily being supported in totality by the government, is being promoted and developed. Yet it is still in its infancy and needs a larger form of support, either through financial support or through some form of reduction in costs, which will allow for increases in production. If possible, these methods of financial support can sustain the farmers through the interim until the process becomes self-sustaining and organic farming of rice becomes financially stable, thereby increasingthe sustainability of organic rice farming. This is important, in that the sustainability of organic farming supports an increase in local biodiversity, which in turn increases the health of the ecosystem and further fosters the sustainability of the process.

Maehwamareum

A human-made rice paddy wetland near the city of Incheon that was purchased by the Korea National Trust Foundation chiefly for its importance as habitat for the herbaceous water plant Maehwamareum (*Ranunculus kazusensis makino*), once common throughout the country but now considered to be endangered and found in only 30 places nationally. Because of eco-friendly rice farming at the site, it also functions as a refuge for aquatic plants, insects, benthic invertebrates, and fish, which become food sources for migratory birds. The site is also used for educational purposes, and an educational centre is in preparation. With a real area of 0.3015 hectares (rounded up to 1 ha.), this is the smallest Ramsar site at the time of designation.

The goal of sustainability, especially for rice cultivation, is to maximize the long-term use while minimizing the loss of ecological characteristics from the rice paddies. By promoting sustainable development of rice paddies and their cultivation, we look to our own futures and that of our children.

An Urgent Need in Asia: Effective Rice Paddy-related Legislation for Wetland and Biodiversity Conservation

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Asian societies take great pride in rice cultivation which plays a significant role in their cultural heritage including agricultural resource management practices.

Rice paddies have many unique characteristics. In fact, the varied agronomic practices on rice production and the series of stages rice crops go though have made rice-fields a haven for a vast array of plants and animal life. To these life forms, paddy fields offer shelter, food, breeding and nesting grounds and also temporary refuge for various migratory species.

The economic and ecological benefits from rice fields, however, are in danger of being lost on account of unsustainable use, invasive species, climate change and pollution - and the things that drive all of these such as poverty and subsidies on utilization of agricultural chemicals. Most damaging is habitat degradation brought about by the rampant conversion of rice paddies to other land uses like human settlements, industrial and commercial sites and aquaculture.

Is the legislation applicable to rice paddies in Asia responsive enough to the need for effective rice paddy management as a man-made wetland and for biodiversity conservation?

Realities of Rice Paddy-related Legislation in Asia

Among the existing rice paddy-related legislation in Asian countries, those on pesticide control, fertilizer use regulation and regulation of other agricultural chemical formulations like insecticides, herbicides, fungicides, etc. are much more evident on statute. The FAO reports, however, that although most developing countries now have a registration scheme, health and environmental problems have not necessarily been reduced. After all, it is not enough to have food security. Quality of life in terms of health and the environment matters too.

Among Asian countries, Indonesia, Vietnam, Korea and Thailand could be cited as examples in regard to pesticide control. Fifty-seven formulations are banned for use on rice to prevent insect resistance and resurgence in Indonesia. In Vietnam, research on beneficial organisms has been carried out concentrating on rice and other main crops. Surveys recorded 2,962 species of insects, 728 diseases on crops, and 209 species of natural enemies on rice. Natural enemies are used in two main ways: by mass rearing and releasing some species into the relevant crop and by protecting and maintaining natural enemies in the crop.

While no requirement exists to test pesticides for their effects on non-target arthropods in Korea, work is underway to determine the impact of specific pesticides on natural enemies including evaluations of the toxicity of a rice pesticide on two rice field spiders. In Thailand, on the other hand, the pesticide control system is governed by the Hazardous Substances Act (1992). Before a product is marketed, full registration is required which includes test results of bio-efficacy and complete toxicological data with two years feeding studies.

Myanmar's Pesticide Law (1990) provide for registration procedures carried out by the Pesticide Registration Board. Approximately 77% of pesticides (90% of insecticides) are used on rice. China's Regulation for Pesticide Registration involves three stages: field test, temporary registration and permanent registration. There is little testing of the effects on beneficial insects with the exception of certain pesticides, or under specific conditions (China is a major pesticide user as well as a producer with an annual output of 220,000 tonnes of active ingredients).

Despite the lack of availability and active government discouragement of their use, chemical pesticides (mostly insecticides) use in agriculture is mostly confined to irrigated rice lands in Lao PDR. Fungicides and herbicides are rarely used which accounts for the high population levels of natural insect pest predators. The country has a Pesticide Law to control the import, manufacture or repacking of pesticides but is yet to be implemented by the Department of Agriculture and Extension.

Apart from agricultural chemical regulation, rice paddy-related legislation in Asia has other objectives. Agricultural policy in the Philippines, for instance, has one vital focus: food security. This is the overall concern of the Agricultural and Fisheries Modernization Law (AFMA) (1997) which is the foundation for all policies pertaining to agriculture. Despite its holistic approach, however, it does not address conservation of rice paddies as wetlands nor does it address biodiversity conservation in rice fields. The closest the law comes to indicating anything in those directions is in providing for an increase in the number of farms engaged in diversified farming. But then, the term is not defined in the law.

Philippine Agenda 21 addresses two aspects of plant genetic resources management. First, it highlights the need to strengthen germplasm and seed banks for indigenous Philippine species. Second, it pinpoints the necessity of re-introducing the use of traditional pest-and-disease-resistant varieties in order to reduce dependency on inorganic chemical inputs in agriculture. When chemical inputs are reduced, genetic diversity flourishes. The targets of Philippine Agenda 21 are still far from being achieved though there are several success stories in the area of plant genetic resources management carried out in various local communities around the country.

That the extent, nature and content of legislative approaches to rice paddy agriculture vary from country to country could be further explained by the fact that there are countries in Asia like Malaysia that have policies on grant of government subsidies to farmers' use of agricultural chemical formulations. In the Philippines, rice lands are the target of the Agrarian Reform Law (1972 as amended) which redistributes lands devoted to rice to the landless as a means of social justice. The Local Government Code (1991), however, allows reclassification or conversion of agricultural lands to other uses such as residential, commercial or industrial. Thailand's Riceland Rent Control Law (1973) limits landowners to not more than 1/3 of the whole yield from the rented land. Fortunately, like Bangladesh, the House of Representatives in Indonesia is currently in the midst of preparing a draft legislation to protect lands reserved for rice production that could lead to sanctions for property developers who illegally build on rice paddies, or conversion for non-agricultural purposes. The main argument is that property development on lands reserved for rice production pose a serious threat to national food security. Of the approximately 7.8 million hectares of irrigated paddy fields throughout the country, more than 140,000 hectares a year are being swallowed up by property development.

Conclusion

The obligation to preserve/conserve paddy fields is not enshrined in the Constitution of any Asian country. If at all, it is deemed incorporated in the constitutional provision on environmental protection or natural resources conservation. There is, in fact, no clear and comprehensive enunciation of policy on rice paddies. It is still developing through pronouncements, directives and guidelines from concerned government agencies particularly the Ministries/Departments of Agriculture, Fisheries, Environment, among others.

A look at legislation revealed that in most countries, provisions related to rice paddies as human made wetlands are distributed across legislations concerning agriculture, land use, water resources, irrigation, agroforestry, fishing, pesticides and fertilizer regulation and, in a few instances, recent legislation dealing with intellectual property rights. Relevant provisions may also be found in hunting, fishing and wildlife regulations. The reasons for this sectoral approach are usually historical or administrative rather than scientific or technical. As a consequence, the range of problems or issues concerning rice fields include: (1) fragmented legal and institutional frameworks (scattered provisions and inconsistent legislative treatment reflected in various agencies and different standards and procedures to prevent harmful impacts); (2) compliance, management and enforcement issues (absence of legally backed monitoring requirements; non-coordination among government agencies; lack of funds and trained personnel on the wise use of rice paddies).

Rice paddy-related legislation in Asia appears inadequate to sustain rice paddy ecosystems. In fact, a review of the same gave the impression that the laws, rules and regulations could even impede or obstruct the objectives of conservation for sustainable development.

Recommendation

Rice paddies as man-made wetlands are acknowledged as one of the most threatened ecosystems in Asia. The conflicts involved in their use and management, their limited areal extent and vulnerability to development pressures call for sound management for which the following recommendations in regard to the legal and institutional aspects are proposed:

1. Countries should develop not only policies on rice paddies but national conservation strategies as well integrating wise use of wetlands principles and implementing such policies by improving institutional frameworks and updating legal measures. Legislation should provide for economic and fiscal incentives and disincentives. Likewise, policy review on grant of government subsidies for agricultural chemical use in rice production should be conducted in order to ascertain informed farmers' decision on chemical application.

2. Emphasis on the inclusion of rice paddies in the wetland management system, supervised by a competent government institution with the aim of instituting efficient site-specific planning and management system to maintain their special characteristics. This would require a clear-cut definition of a rice paddy as a man-made wetland. Guidelines for the purpose would be helpful in considering the scope of eventual regulatory action to properly manage the area.

3. Re-examination and harmonization of pertinent laws should extend to the political will evidenced by the availability of funds, personnel, technical information and infrastructure required for monitoring and enforcement. Enforcement jurisdiction should consider the village level where rice paddies are located.

4. Sound rice paddy management need management plans with the following objectives: (i) To preserve rice paddy ecosystems for the protection of genetic resources and biological diversity; (ii) To conserve resources, e.g. plants, insects and animals, physical space or land for the maximum benefit of the people; (iii) To avoid conversion uses, e.g. housing development, aquaculture, recreational sites and even agriculture that eliminate/deplete the resources found therein. For greater effectiveness, legitimization of management plans could be done through its adoption by local government legislative assemblies or executive boards or village councils.

5. A determined implementation of rice paddy-related legislation could be rendered more effective by providing applicable laws and regulations with guidelines for easier compliance with requirements. Improved coordination among agencies will also achieve effective law implementation. In this regard, public information, awareness and understanding could be tied up with community development programs, religion-related or civic groups and village gatherings.

Asia faces challenges in managing its agricultural and environmental resources from the loss of wetlands. In connection therewith, there is the opinion that traditional farmers are always right and that modern science is the cause rather than the possible cure for the serious environmental problems associated with agricultural development in the region. Often cited is the Green Revolution launched in the 1970s which allegedly replaced traditional agricultural systems with modernized methods of farming. Some even blame technology for the loss of genetic diversity, excessive use of chemical fertilizers and pesticides and the pollution of soil and groundwater.

Perhaps, the best view is that farmers and scientists are both correct, meaning, all efforts to try to understand management of agricultural resources and the environment from the perspective of both farmers and scientists should be given serious thought. In this regard, integration of scientific research and public education would be most practical, maximized by promoting collaborative efforts. Specifically, what kinds of species depend on rice paddy ecosystems? What integrated management practices ought to be adopted for wise use of paddy fields? Do countries which grant subsidies have informed decisions *vis-a-vis* the ecological and health consequences of such use? After thorough consideration, clear policies, rules, regulations and guidelines could help in implementing responsive-to-challenges rice paddy-related legislation for effective wetlands and biodiversity conservation.

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Res X.31: Enhancing biodiversity in rice paddies as wetland systems

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Resolution X.31 was adopted at the 10th Meeting of the Conference of the Contracting Parties to the Convention on Wetlands, held in Changwon, Republic of Korea from 28 October to 4 November 2008.

The Resolution recognizes the important ecosystem services provided by rice paddies: rice forms the staple diet for over half the world's population, and is the source of other animal and/or plant food sources and medicinal plants, thus acting as wetland systems and helping to sustain livelihoods and human well-being. Rice paddies in some parts of the world also support important wetland biodiversity, such as reptiles, amphibians, fish, crustaceans, insects and molluscs, and play a significant role in waterbird flyways and the conservation of waterbird populations.

It notes current and potential threats to the role of rice paddies as sustainable wetland systems, as well as about the potential and current impacts to the surrounding environment, caused by factors such as inappropriate agricultural practices relating to water management and change of natural flow, as well as introduction of new taxa, including invasive alien species, use of high levels of harmful agricultural chemicals, and the impact of inappropriate conversion of rice paddies to other land uses.

The focus of this Resolution is specifically on the maintenance and enhancement of the ecological and cultural role and value of appropriate rice paddies as wetland systems, consistent and in harmony with the Convention, internationally agreed development goals, and other relevant international obligations;

The key operative paragraphs of Resolution X.31 are paragraphs 17 & 18, which calls for specific actions to be taken to ensure the conservation and wise use of rice paddy ecosystems:

Paragraph 17(i): Identify challenges and opportunities associated with managing rice paddies as wetland systems in the context of the wise use of wetlands, also paying attention to the concept of connectivity between rice paddies, natural wetlands and river basins, as well as to the promotion of sustainable agricultural practices, and furthermore to encourage conservation authorities to collaborate with agriculture authorities and those agencies responsible for rice production and disease prevention to identify and actively promote planning, farming practices, and water management in rice paddies that serve to enhance the natural biodiversity, ecosystem services, and sustainability of rice paddies, while also contributing to improved nutrition, health and well-being of farming household members and surrounding community members and to the conservation of waterbird populations.

Paragraph 17(ii): Ensure that such planning, farming practices, and water management are implemented wherever applicable, making appropriate use of the Ramsar guidance on wetlands and river basin management adopted in COP10 Resolution X.19 so as to ensure that river basin processes and possible upstream and downstream effects of rice paddy farming are considered, while being conscious of the need for food production and the interests of local communities.

Paragraph 17(iii): Ensure that planning, farming practices, and water management associated with rice paddies do not lead to loss of existing natural biodiversity and ecosystem services through inappropriate conversion of natural wetlands or other habitats to human-made wetlands.

Paragraph 17(iv): Consistent with the measures identified above, seek appropriate environmentally sustainable ways of minimising risks to human health associated with waterborne diseases, disease vectors (including Highly Pathogenic Avian Influenza), and excessive and inappropriate use of agricultural chemicals in rice paddies.

Anticipated products

Paragraph 18 requests the Scientific and Technical Review Panel, working with other interested organizations, to:

Paragraph 18 (i): Prepare a **technical report** on the role of rice paddy in supporting the conservation of wetland biodiversity and the delivery of wetland ecosystem services, taking into account differences in the ways in which rice fields are managed, considering also the work of the GAWI partnership; and

Paragraph 18(ii): Review, disseminate, and exchange available guidance and information related to rice paddy planning, management practices and training on sustainable rice farming that protect or enhance wetland biodiversity and ecosystem services while also supporting essential food production, in collaboration especially with FAO, IWMI, the International Rice Research Institute (IRRI), the Africa Rice Centre (WARDA), the GAWI partnership, and others.

This workshop seeks to identify sustainable rice paddy farming practices in Asian region that reinforce wetland conservation objectives and provide ecosystem services, which can be used for the compilation of the technical report.

However, Paragraph 17 also deals with issues related to the management of the rice paddy ecosystem, which remain to be discussed and deliberated. Some of these are presented below as food for thought:

- What legislative and regulatory frameworks, and planning and decision-making processes are needed to support the conservation and wise use of rice paddy ecosystems?
- At what scale should we address the management of rice paddy ecosystems – plot, farm, or landscape?
- The connectivity between rice paddies, natural wetlands and river basins.
- What ecosystem services are provided by rice paddies and how do we quantify/value these?
- How do we ensure that biodiversity, agricultural productivity and profitability, and ecosystem services intersect?

Additionally, there is the question of how we deal with the predicted impacts of climate change. Two universal trends are predicted by all climate change models: (a) temperatures will increase, resulting in more heat stress and rising sea levels, and (b) there will be more frequent and severe climate extremes. Any significant negative effect on rice production would be devastating for efforts to achieve global food security and address poverty.

- How do we ensure the resilience of rice paddy ecosystems?

There is no global challenge facing humanity that is more important than managing the earth's environment to assure that it can sustain life in all its forms. The ecological balance on which current and future generations depend can only be preserved through food chains that balance energy and nutrient flows. The challenge is to balance the competing demands of different users of the same resources and of managing the resources to optimise the benefits to be derived on a sustainable basis.

Resolution X.31 presents an opportunity for the Ramsar community to seek and implement ways to do this for the rice paddy ecosystem.

Beyond CBD COP10:
Case study on Kabukuri-numa and surrounding rice paddies

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Abstract

Over the past century, Japan's wetlands have become greatly impoverished, suffering irrecoverable losses of 61%. Notable is Miyagi Prefecture, which has lost 92% of its wetlands, mostly as a result of their conversion into rice paddies. Ibaragi, Chiba and other prefectures also share similar histories. Higher yields and efficiency have further fueled the construction of paddies, and in keeping them dry in winter has eliminated their remaining wetland values, particularly along Japan's more arid Pacific coast. This has seriously impacted many wetland-dependent species, driving some close to extinction.

By presenting the case of the Ramsar site "Kabukuri-numa and surrounding rice paddies," this paper takes a 100-year perspective in discussing the enhancement of the wetland values of rice paddies as a way of restoring wetland environments and sustainable local communities. Here, the co-existence of rice agriculture with over-wintering geese is being sought through the re-conversion of some paddies back to wetland, and winter-flooding others still under cultivation.

The opportunity for stakeholders to initiate a movement for wetland protection and co-existence of wildlife with agriculture first arose with the opposition to a proposal to dredge Kabukuri-numa wetland. Landholders then agreed to re-convert 50 hectares of paddy fields back to wetland in 1998. As a result, the number of geese using Kabukuri-numa as a roosting site increased, demonstrating that the restoration augmented the site's wildlife carrying capacity. Furthermore, farmers and others cooperated to implement a winter-flooding regime for nearby cultivated paddies. In this paper, this project is examined from various standpoints including its application of the Ramsar Convention and Resolution X.31 "Enhancing biodiversity in rice paddies as wetland systems" (hereupon Rice paddy resolution X.31), its role as a bridge to CBD COP10, with achievements and issues identified.

Normally, once a wetland is destroyed, restoration requires huge commitments of time and money. However, restoration through the management of rice paddies as "agricultural

wetlands" can be a realistic and effective method for restoring natural wetland environments in Asia.

1. Introduction

According to the Geographical Survey Institute[1)], 61% of Japan's wetlands have disappeared over the last century. In the early 20th century, Miyagi prefecture was ranked 3rd in wetland area but later experienced losses of 92%, resulting in the highest rate of loss and extreme change to wetlands in Japan. In this age of increasing demand for food, most reclaimed wetlands were converted into rice paddies, of which low-lying alluvial plains were actively targeted. Chiba and Ibaragi prefectures, which also have alluvial plains, sustained wetland losses of about 90%.

Rice paddies that have replaced natural wetlands are also changing. Those reclaimed earlier on are mostly "wet" paddies, in contrast to those reclaimed in the last quarter of the 20th century, which are qualitatively different. The development of civil engineering technology and agricultural policies favoring efficiency and productivity resulted in paddies built or re-built with excellent drainage, thus allowing for the use of large-scale machinery and conversion to dry fields for non-rice crops, a trend that continues today. For example, in Miyagi in 2000, 77.5% of a total of 21,883 hectares (ha) undergoing agricultural improvement at 104 sites was transformed into dry-field convertible fields.

These losses of natural wetlands and the qualitative changes in rice paddy environments have had major negative impacts on wetland-dependant species groups. In the quest to feed humans, most paddies were created by destroying natural wetlands. However, they differ significantly from other agricultural fields in that they are flooded to grow rice, a wetland plant and thus *function* as wetlands. They can also be continuously cultivated for long periods of time without impoverishing the soil.

Appropriate water management is required to activate the wetland functions of rice paddies. Traditionally, water was retained in paddies during winter and so they functioned as semi-natural but still important habitats for wetland-dependent wildlife. However, in modern times the practice of letting fields completely dry out during winter spread rapidly, robbing paddies of wetland functions and helping drive many wetland species towards extinction, such as the Japanese Crested Ibis and White Stork, both extinct in the wild in Japan. Waterbirds such as geese, swans and ducks use these wetlands in winter and feel these impacts most strongly.

This paper introduces efforts at Kabukuri-numa to restore the wetland values of rice paddies as agricultural wetlands and achieve co-existence with environmentally-sensitive geese, efforts that consciously recall wetland environments of 100 years ago. It discusses ways, including the application of the Ramsar Convention, for restoring wetlands and sustainable local societies.

2. Action for co-existence of waterbirds and wet rice cultivation at Kabukuri-numa and the surrounding rice paddies

"Kabukuri-numa and the surrounding rice paddies" in northern Miyagi prefecture is the 1545th wetland on the "List of Wetlands of International Importance" of the Ramsar Convention, an intergovernmental treaty dedicated to the conservation and wise use of wetlands. Added to the List in November 2005, it was the first Ramsar site to expressly include surrounding rice paddies as an agro-wetland buffer zone to an open-water wetland. Although rice paddies normally impose environmental burdens due to intensive agricultural methods, public indifference to wetlands, etc., they can help maintain wetland ecosystems.

In order to reduce or eliminate these burdens, the first requirement is increased awareness and agreement among the local community that rice paddies are valuable buffer zones for wetlands. At Kabukuri-numa, incentives to meet this requirement included discussions and agricultural/environmental policies designed to reduce environmental burdens and activate the wetland functions of paddies. The consensus reached by local farmers to apply the Ramsar Convention as a framework for allowing wildlife to share wetland benefits led to the area's designation to the List.

2-1. profile of Kabukuri-numa Marsh

Location: Tajiri, Ohsaki City, Miyagi Prefecture/ **Ramsar Site**: Wetland of 150 ha and surrounding rice paddies of 273 ha as buffer zone (since 2005)/ **Rich fauna and flora**: 219 species of wild birds（6 Natural Monument spp. & 42 RDB spp.）, 33 species of fish, 10 species of shellfish, 19 RDB species of plant/ **Feature:** Important roosting sites for wild geese and leading project for promoting co-existence of rice farming with waterbirds through recovery or restoration of wetland habitat

2.2 Wetland transitions around Kabukuri-numa and the 100-year restoration plan

Though Kabukuri-numa formerly had a larger area of open water, reclamation of much of the wetland has left only 100 ha of open water. This is a major reason for the present intensive concentration of natural habitat for geese and other The "Hundred-year

Open-Water Restoration Plan" was thus designed to restore balance to these wetland environments.

Over the last 100 years, many of Japan's wetlands were reclaimed as paddy land, of which most was further transformed into paddies that are completely dried out in winter. The Hundred-year Plan's main purpose is to take the next 100 years to restore these wetlands to an approximation of their former status through water management and rice cultivation that allow paddies to function as wetlands. Specifically, the project educates local stakeholders and proposes a flooding regime to keep water in paddies as long as possible to reactivate their wetland functions. Its fundamental principles are: 1) Abandoned rice paddies should be amalgamated and restored as natural wetlands; 2) Fallow paddies should be flooded year-round and managed as wetlands; 3) Paddies with good water retention should be managed under a "winter-flooding" regime; 4) These activities should be undertaken with the support of all stakeholders in agriculture, environmental protection, water management, etc. Implementing these principles required a revolution in the consciousness of farming families, and the establishment a system of incentives and guidance by government authorities.

By the late 20th century, actions leading up to this project were already underway. The "Kabukuri-numa Retarding Basin Project" was a flood control measure first undertaken by Miyagi prefecture in 1970 that targeted 582 ha of Kabukuri-numa and its vicinity for retaining floodwater overflow. In 1996, a plan was revealed calling for the entire area to be dredged by one meter as it had allegedly become shallower due to sediment accumulation. This proposal in effect provided opportunities to protect Kabukuri-numa; environmental studies preceding its implementation led to a complete reconsideration of the project. Lessons were learned about considering only flood-control factors and not releasing information on retarding basin construction plans. At the request of environmental conservation groups and others [2,3], an informal deliberative council, the Kabukuri-numa Round Table Meeting was established by the Rivers Department of Miyagi prefecture to discuss ways to conserve a rich natural environment while maintaining flood control. The Round Table pursued constructive discussions and actions to reach consensus among stakeholders, including fundamentally changing the overflow embankment plan to include environmental concerns. These concepts were then included in the "Kabukuri-numa Basic Environmental Management Plan," based on the Round Table's discussions and is summarized as follows: 1) Maintain Kabukuri-numa's function as a floodwater retarding basin in a way that allows it to fulfill its other roles and functions; 2) Protect the river environment as a habitat for diverse, precious wildlife; 3) Create and use the area as a place for humans to relate with the natural environment; 4) Residents and authorities should act as a single entity in managing Kabukuri-numa.

2.3 Effects of the Shiratori restoration on Kabukuri-numa's environmental carrying capacity

One of the most important developments of this project was returning paddies in the Shiratori area within the Kabukuri-numa retarding basin to wetland status, as it increased the carrying capacity of the wetland overall. In 1997 farmers agreed with local and prefectural authorities to withdraw this area from cultivation. Based on an agreement between conservation groups and the river management authority, a regime to routinely keep the area underwater was adopted in spring, 1998. Thus, Shiratori was restored as a natural wetland and became an integral part of Kabukuri-numa, increasing its area by 1.5 times to 150 ha.

The total number of White-fronted Geese wintering in Japan has been on an upward trend, more markedly in the 1990s. The greatest number once roosted at Izunuma, but this began to change after restoration started at Kabukuri-numa. Before a voluntary ban on gun hunting in Kabukuri-numa was adopted in the winter of 1994-1995, a relatively low proportion of geese roosted there, but afterwards numbers started to rise. In the second winter following the Shiratori restoration (1999-2000), their numbers surpassed those of the previous hotspot Izunuma, a trend that has since remained unchanged. This indicates that the increase was not due to an enhanced carrying capacity in the former Kabukuri-numa, but to the Shiratori restoration and the creation of more open water[4)].

2.4 The Winter-flooded Rice Paddy Project

Monitoring the Shiratori area during and after restoration suggested that given the appropriate circumstances, shallowly flooding rice paddies in winter could create new goose roosting sites. This led to the Winter-flooded Rice Paddy project, started in winter 1998-1999 in Tajiri Township (now Ohsaki City), home of Kabukuri-numa. With the cooperation of farmers owning and cultivating rice paddies within the habitat range of geese roosting at Kabukuri-numa, the paddies were flooded during winter to create new roosting sites and disperse over-concentrated waterbird populations[5,6,7)]. In flooded paddies, most of which were surrounded by dried-out paddies, swans by day and ducks by night were frequently seen, and with time even extremely shy White-fronted Geese were occasionally observed. This demonstrated that winter-flooded rice paddies could attract White-fronted Geese and other birds, offering an efficient way to extend habitat[4,5)] and alleviate over-concentration, a serious issue for geese. The birds do not feed but rest, drink and preen in these paddies. Given an absence of disturbance, they will stay the entire day in an area with winter-flooded paddies, though normally not at night. Stronger efforts by farmers, better national networking and support systems and an increase in the scale of projects could create many new goose roosting sites.

Winter-flooded rice paddies benefit not only over-wintering waterbirds, but also those using the paddies in summer. Rice paddies in the Shimpo area next to Kabukuri-numa, where farmers flood a concentrated group of rice paddies in winter were monitored over 2 years (2005, 2006) for benefits to waterbirds, with the assistance of funding from the Ministry of the Environment [4,8]. These surveys showed benefits to over-wintering geese, etc., and also clear and significant benefits to herons (*Ardeidae*) in summer, when the paddies are cultivated as usual. The main *Ardeidae* visiting the area are the Intermediate Egret, Great Egret, Cattle Egret, and Gray Heron, which use it mainly to feed. Depending on the water level, they catch loach, frogs, or red swamp crayfish (*Procambus clarkii*) [4]. The concentration of *Ardeidae* at winter-flooded paddies was 3.6 ~ 3.8 times greater than in other paddies. The Great Egret (2.7~5.0 X) and Intermediate Egret (3.0~4.0 X) clearly and consistently selected winter-flooded paddies[4], where the concentration of loach and Tubificid worms that are eaten by loach, was about 5 times greater than in other paddies[9]. These results indicate that winter-flooded paddies have higher biodiversity and greater biomass in both winter and summer, leading to higher concentrations of top predators such as *Ardeidae*.

Winter-flooding is attracting attention as a new agricultural method that brings rice-paddy ecosystems to life[7, 10], and as a result more farmers are applying its methods or are showing interest[11]. Also, Kobayashi et al. [12] suggest that White-fronted Geese shuttling between rice paddies and open water may contribute to the local material cycle.

We can summarize that winter-flooded rice paddies function as follows: 1) They restore habitat for biota that naturally inhabit wet rice fields, enhancing biodiversity ranging from micro-organisms to waterbirds, and could help restore the migratory flyway of geese; 2) Proliferation of Tubificid worms from winter flooding creates a soil layer composed of worm feces, etc., that controls weeds. Waterbirds fertilize the paddy, helping decompose rice straw. Higher concentrations of insectivorous spiders, frogs, etc. employ the paddy's ecosystem power to assist agriculture; 3) They help create a sustainable, recycling local society based on co-existence/symbiosis between nature and agriculture.

3. Wise use of rice paddies as agro-wetlands

3.1 Co-existence between waterbirds and rice agriculture

Both waterbirds and humans inhabit most sites on the Ramsar List, and so it is worthwhile to highlight the co-existence/symbiosis between them. Kabukuri-numa is one of the most important wintering sites for geese in Japan, making it an attractive and interesting spot to observe them. However, local farmers were hostile to the geese, regarding them as pests harmful to their rice crops. This hostility thwarted several past attempts to have Kabukuri-numa designated a Wildlife Protection Area, but in 2005 it attained Special National Wildlife Protection Area status.

The first step towards this rapprochement was in 1996 when the dredging plan was proposed. The plan however was cancelled due to joint opposition by conservationists and farmers, thus averting a major threat and creating an opportunity to reconsider the meaning of the geese's presence at the site. This was when the farmers' views on the geese began to change. Geese are extremely sensitive to environmental change, requiring a large area of undisturbed, shallow open water to roost and an extensive area of rice paddy land on which to feed[13, 14, 15)]. Farmers came to appreciate that about 80% of wild geese over-wintering in Japan chose Kabukuri-numa and other northern Miyagi sites, in the sense that geese choose the richest paddies, which in turn can produce safe, premium rice. Farmers stopped attempting to drive the geese out and instead started devising ways to use the geese's presence to an advantage. Although these farmers achieved a change in attitude, this was significantly supported by the Winter-flooded Rice Paddy project and by a change in the approach towards agriculture taken by the Ramsar Convention itself.

3.2 The Ramsar Convention as a tool for activating rice paddies as wetlands

The Ramsar Convention defines all watery areas, including rice paddies, as "wetlands." Most rice paddies are created by humans reclaiming natural wetlands for agriculture, but unlike many other types of agricultural fields, rice paddies can be used sustainably for thousands of years and function as valuable agricultural wetlands providing habitat for wildlife. Rice paddies also account for the greatest area of wetlands in the rice-growing countries of Asia; in Japan alone they cover about 2.6 million ha (2002). Rice paddies have been valued exclusively as rice production units, but recently their wetland functions have attracted more attention as well.

In 2002, the 8th Conference of the Contracting Parties (COP8) to the Ramsar Convention (Valencia) adopted Resolution VIII.34 "Agriculture, wetlands and water resource management," the first resolution dealing directly with agriculture. This resolution calls upon Contracting Parties to "ensure that management plans for Ramsar sites and other wetlands … duly acknowledge the need for appropriate implementation of agricultural practices and policies that are compatible with wetland conservation and sustainable use goals…" and urges them to identify and enhance positive incentives and replace negative incentives with ones that contribute to wetland conservation.

This resolution significantly influenced the opinions of farmers in the Kabukuri-numa area regarding the Ramsar Convention. Farmers that formerly perceived it as "regulatory," and consequently refused to allow their land to be included in the Ramsar site changed their minds and actively sought designation and application of the Convention as the framework for drawing up environmental policy for agriculture. This change of heart initiated the movement for making Japan the first country to intentionally designate rice paddy land.

“Kabukuri-numa and surrounding rice paddies” was included on the List at COP9 (Kampala, 2005), when Japan designated 20 new Ramsar sites, bringing its total to 33 (37 at present) sites. Eleven (fifteen at present) of these were located in or near rice paddies, but only at Kabukuri-numa are stakeholders using the Convention to add environmental value to agriculture in creating a site comprised of open water and rice paddies.

Developments at Kabukuri-numa attracted much attention at COP9; at Japan’s ceremony to officially designate its new sites, Peter Bridgewater, then Secretary-General, warmly welcomed the designation of a site including agricultural land. Rice paddies surrounding an open-water wetland can play an important role as a buffer zone that helps maintain its distinctive ecosystem, and managing the two as a unit can enhance total wetland function. Only 2 of Japan’s 15 sites located near paddy land include rice paddies, and only Kabukuri-numa expressly includes them.

Extending existing Ramsar sites by including paddy land could be the next step. For example, rice paddies around the Lake Biwa serve as spawning sites for *nigoro-buna* (*Carassius auratus grandoculis*), a carp relative endemic to Lake Biwa. This Ramsar site is presently limited to the lake surface; extending it to surrounding rice paddies upstream where the fish spawns could encourage use of the Convention to promote wise use of this fishery resource. The Izunuma Ramsar site is also limited to the lake area, but the area of surrounding rice paddies is an important feeding ground for geese and other species, and has already been designated a Special National Wildlife Protection Area. With a little more local initiative, this site could easily be extended as well.

Ramsar Site *Kabukuri-numa and the Surrounding Rice Paddies:*

A new concept

- First Ramsar Site involving large area of rice paddy, a typical Asian wetland, under agreement of most stakeholders
- New concept for Ramsar as a useful tool for agro-environmental rice farming
- Setting the foundation for Ramsar Rice Paddy Resolution X.31
- First step for increasing waterbirds and achieving profitable agriculture

3.3 International focus on Asia's largest wetland – the rice paddy

Farmers cultivating rice paddies directly south of Kabukuri-numa agreed to flood an amalgamated area during winter to reactivate its wetland functions. Although some unresolved issues with this agricultural practice remain, biological diversity has definitely increased and the area's value as an agricultural wetland continues to grow. The main issue now is how to stabilize the business side of producing rice of higher value (organic winter-flooded paddy rice is normally double the price of ordinary rice) through sustainable practices and less environmental impact putting the natural powers of the rice paddy as a wetland to use, in the spirit of the Ramsar Convention. Doing so will help bring back wetland environments even more favorable to waterbirds and other wetland-dependent species groups.

Rice paddies are the representative agricultural land of Japan and the Asian monsoon region, and occupy its greatest wetland area. This region has Earth's richest soils and high levels of precipitation, making it suitable for growing rice, a wetland plant. Because of their distinctive wetland characteristics, rice paddies can serve as habitat for a variety of wetland-dependent species, and designation of Kabukuri-numa to the Ramsar List has initiated a reconsideration of the values of Asia's rice paddies. To illustrate, in 2005 Japanese and South Korean non-governmental organizations held a side event at Ramsar COP9 in Uganda to focus attention on the biodiversity and wise use of rice paddies in the Asian monsoon region. This meeting strategically anticipated COP10 to be held in the Republic of Korea in 2008, where a further appeal would be made regarding the potential of Asia's rice paddies as agricultural wetlands. This NGO meeting recognized the following points: 1) Rice paddies are a characteristic Asian wetland type and important habitats for migratory birds and many other species; 2) Socio-economic changes have caused rapid degradation and loss of rice paddies; 3) Winter-flooded rice paddy projects in Japan and Korea deserve attention as a method for restoring the wetland functions of rice paddies; 4) A resolution recognizing the wetland value of rice paddies in the Asian monsoon region should be adopted at Ramsar COP10.

Future issues include extending the movement started at Kabukuri-numa further into the neighboring wet-rice culture of Korea, and using Ramsar COP10 as a foothold for identifying and following up on ways to extend it to other East Asian countries.

4. Rich and diverse biota of rice paddy ecosystem and its importance

Rice paddy ecosystems, maintained by a complex network of life, provide habitat for 5,688 species of flora and fauna. Its importance was also recognized in the form of the Rice Paddy Resolution X.31 at Ramsar COP10 (Changwon, 2008), through the initiative of both Korean and Japanese governments and NGOs. There is now greater international recognition that rice paddies have extensive wetland functions supporting rich biodiversity, in addition to their function as agricultural land. The biodiversity of rice paddies highlighted in Ramsar Resolution X.31 may provide opportunities for future cooperation between the Ramsar Convention and the Convention on Biological Diversity (CBD).

As a sustainable agro-wetland for millennia, rice paddies play a part in the global water cycle system. Rice paddies serve as buffer zones to natural wetlands, are rich in biodiversity and are highly productive, and not just in terms of rice. For instance, approximately two-thirds of the animal protein consumed by Laotians comes from rice paddies.

5. Targets for Ramsar COP11: Beyond CBD COP10

At CBD COP10 in Nagoya in October 2010, a decision on agricultural biodiversity （UNEP/CBD/COP/10/L.33） including paragraphs on rice paddies proposed by the Government of Japan with support from Japanese NGOs was adopted. This decision welcomes Resolution X.31 of Ramsar COP10 on the subject of "Enhancing biodiversity in rice paddies as wetland systems" and recognizes the relevance of Resolution X.31 in the implementation of work on agricultural biodiversity and invites relevant Parties, as appropriate, to fully implement this resolution.

Advice was also received from Nick Davidson of the Ramsar Convention Secretariat during the decision-making process of SBSTTA14 in May, 2010 including the following details:

- Recognition of the importance of appropriately managed rice paddy for wetland biodiversity
- Inclusion of text on rice paddies in the SBSTTA recommendations can facilitate future implementation of the Ramsar-CBD Joint Work Plan in relation to human-made inland wetlands

The following are recommended targets for Ramsar COP11, beyond CBD COP10:

- Implementation of the Ramsar-CBD Joint Work Plan in relation to human-made inland wetlands

- Establishing a 10-year Programme of Enhancing Biodiversity of Rice Paddies especially in Asia, in conjunction with UN Decade of Biodiversity, which was ccepted at CBD COP10

- Request to relevant national governments to include Ramsar Rice Paddy Resolution X.31 into their respective national strategies for biodiversity

- Request to relevant local governments to include Ramsar Rice Paddy Resolution X.31 into their respective local strategies for biodiversity

- Increase the number of new Ramsar sites focusing on rice paddies

- Spread the area of existing Ramsar sites to include surrounding rice paddies

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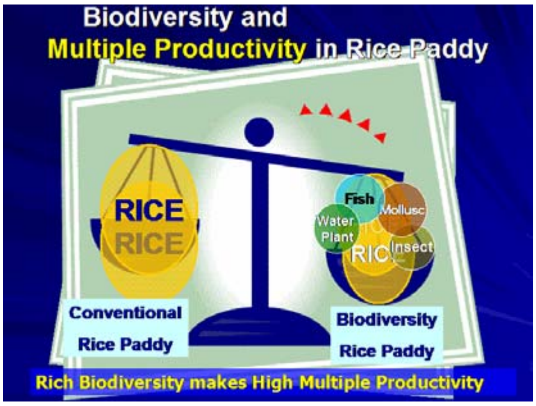

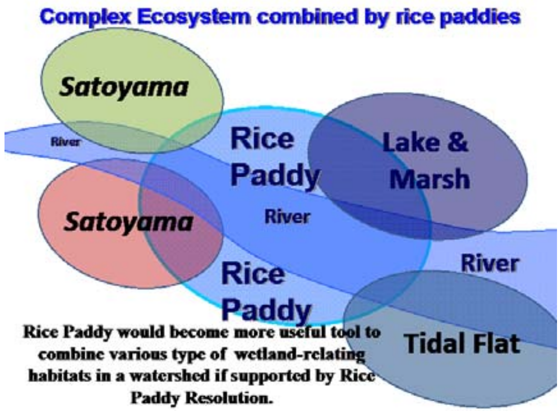

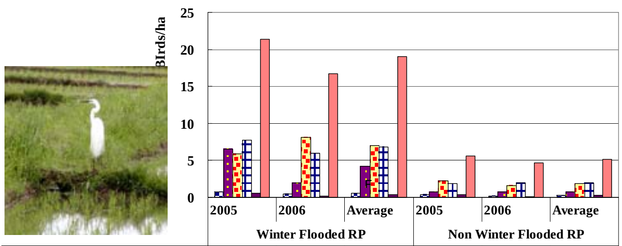

	Winter Flooded RP 2005	Winter Flooded RP 2006	Winter Flooded RP Average	Non Winter Flooded RP 2005	Non Winter Flooded RP 2006	Non Winter Flooded RP Average
Grey Heron Ardea cinerea	0.73	0.45	0.59	0.35	0.20	0.28
Cattle Egret Bubulcus ibis	6.50	1.98	4.24	0.78	0.77	0.77
Great Egret Egretta alba	5.85	8.16	7.01	2.19	1.62	1.91
Intermediate Egret E. intermedia	7.70	5.94	6.82	1.91	1.97	1.94
Little Egret E. garzetta	0.58	0.20	0.39	0.39	0.14	0.27
Total	21.35	16.73	19.04	5.63	4.70	5.16

Winter-flooded Rice Farming and Heron Density in Summer

(Average　in 2005 & 2006 summers n=1,980)

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CONFERENCE OF THE PARTIES TO THE CONVENTION ON BIOLOGICAL DIVERSITY
Tenth meeting
Nagoya, Japan, 18-29 October 2010
Agenda item 6.1agricultural biodiversity

Draft decision submitted by the Chair of Working Group I

The Conference of the Parties

. . . .

18. *Welcomes* resolution X.31 of the tenth meeting of the Conference of the Parties to the Convention on Wetlands (Ramsar, Iran, 1971) on the subject "Enhancing biodiversity in rice paddies as wetland systems" which notes, *inter alia*, the culture of rice in 114 countries worldwide, that rice paddies (flooded and irrigated fields in which rice is grown) have provided large areas of open water for centuries and that they support a high level of rice associated biodiversity important for sustaining rice-paddy ecosystems, as well as providing many other ecosystem services, *recognizes* the relevance of this resolution to the implementation of the programme of work on agricultural biodiversity and *invites* relevant Parties, as appropriate, to fully implement this resolution;

19. *Recognizes also* the importance of agro-ecosystems, in particular rice-paddy and oasis systems, for the conservation and sustainable use of biodiversity, and *invites* the Food and Agriculture Organization of the United Nations, subject to resources, and in consultation with the Executive Secretary and relevant partners, including indigenous and local communities, to undertake further studies on the valuation of the biodiversity and ecosystem services provided by agricultural ecosystems, in order to further support policy-relevant guidance to Parties for consideration by the eleventh meeting of the Conference of the Parties, consistent and in harmony with the Convention on Biological Diversity and other relevant international obligations.

--(end)----

Intensification of Malaysian rice agro ecosystem based on sustainable development in enhancing rice production

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Introduction;

The 10th Malaysia Plan (10MP) had been launched on the 10th June 2010 by Datuk Seri Najib Tun Razak the Prime Minister of Malaysia. The main aim is to propel the country towards a high-income and high productivity economic nation. Agriculture including rice production is in the 12 National Key Economic Areas (NKEAs) under the 10MP having great potential to generate high income for the nation.

Malaysia is moving toward a developed country status. Although its industrial sector is fast growing, however agricultural sector is not neglected. Food security particularly rice is still receive the attention of policy makers. It has always been the Malaysian Government priority to grow rice for its own people. Under the National Agricultural Policy, rice has been target to achieve self sufficient level. However several constraints such as land shortage, water use efficiency, high price of fertilizers and pesticides, labor shortages and less adaptation of new technology need to be addressed and rectified first.

The country is trying hard to achieve its target and subsequently committed to increase rice production. In order to raise the rice production and to become self-sufficient level (SSL), strategies have been planned within 10MP. It is forecast that this crucial commodity is going to be short supply in future. As stated land shortage is one of the major constraints. Therefore with limited agricultural lands, intensification of the existing agricultural land is the best option.

On the contrary due to massive developments in China, India and Southeast Asian countries, Asian rice stocks are near danger level and unfortunately the world grain stocks have reduced by half since 1999. A reserve grain stock that could feed entire world for 116 days could only stand for 57 days. The global rice stock has an impact of imported rice to Malaysia. Therefore Malaysia could not depend too much on these Asian countries.

It should be noted that severe price escalation in imported rice was experienced by Malaysia in 2008. This was due to short supplied of rice imports from Thailand, Vietnam, India and China. Currently Malaysians annually consume about 2.2 million tons of rice of which 657,900 tons still need to be imported. Generally price range from RM 1.65 to RM 1.80 per kilogram of good quality rice.

Crop productivity;

The second green revolution started in the late 1960s when high-yielding varieties of rice were designed to overcome the predicted hunger crisis. Irrigated rice fields are observed to replace most rice rain-fed farming areas. Gradual increased in rice productions are recorded from several countries that adopting new cultivation technique particularly uses of improved rice varieties and efficient use of water. In addition soil characteristics showed a high pattern of variability in a complex rice agro ecosystem. For example nitrogen content remained at high levels during the crop period, however will be leaching with maximum values at the end of harvesting season. Therefore the different sources of flooding water and the fertilization input could have a strong impact on the soil chemical characteristics.

Intensification of existing rice bowl areas particularly MADA rice granary area in Peninsular Malaysia and in establishing new rice bowl areas in Sarawak and Sabah on the Borneo Island, West Malaysia, is the Malaysian Government effort in increasing rice production. The landscape of the new rice fields need to study first and environmental assessment should be conducted on the environmental condition of a new area.

One of the aims of the 10MP is to propel Malaysia to be one of the global rice exporters. The Second Malaysian Plan from 1971 to 1975 had greatly modernized the rice bowls of Kedah and Perlis. Unfortunately the usage of an ecological friendly animal water buffalo is virtually eliminated in rice agro ecosystem. Perhaps the issue of using water buffalo should be studied. In fact water buffalo should be reintroduced to the rice fields.

Tractors and other modern farm equipments are replacing the tradition usage of buffaloes and human labors. Perhaps the modern techniques are tallied to cultivation of new rice hybrids. Although the rice production is increased, however the negative ecological impact on the rice agro ecosystems is relatively high.

Rice cultivation is the principal employment and source of income for approximately 100 million farmers in Asia and to certain extent in Africa. Most countries are dependent on rice as a source of foreign exchange. To date most small holders and individual farmers did not benefit very much from modern agricultural technology due to limited capital inputs.

Through technology particularly mechanization and introduction of modern rice varieties could be the key factors that could contribute to Malaysia's increasing rice yield despite decreasing rice lands. Rice has become the main livelihood to about 296,000 farmers and 40% are exclusively rice farmers. It means about only 1% of total populations are rice farmers. Rice is grown by small holders. An average farm size is about 1 ha and it is about 86% of grain production of the nation.

The agricultural sector provides high quality raw materials to industrial sector under the agro and resource based industrial development strategies of the government. The Malaysian agricultural sector can be primarily grouped into three sub-sectors. First, the agro-industrial sub-sector which comprise oil palm, rubber, cocoa and timber. These resources serve the export market. Second, the food sub-sector includes rice, fruits, vegetables, livestock and fisheries largely serve domestic consumption. The third sub-sector is the miscellaneous group which consists of tobacco, pepper, coconuts, sugar cane, cassava, sweet potato, maize, tea and coffee which cater to both the domestic and export markets.

Undeniably rice is regarded as the most important crop in the food sub sector in Malaysia. Therefore food security is tallied with rice security. Apparently rice self sufficiently policy is the appropriate approached by the Malaysian to cater for the country's need. New Economic Policy (NEP) on the rice farming in Malaysia is currently based on the examination of the currently policy. It needs to rectify and subsequently improved. Institutional and technological changes that have taken place should be enhanced.

The general objectives are to support and increase farmer incomes, to promote rice production to the level of self-sufficiency and to ensure consumers of rice quality at reasonable prices. Among these factors, apparently priority is placed on the hydrological system such as irrigation development and technological innovation. By improving the drainage and irrigation systems, water supply into the rice field is efficiently. Since rice is a wetland plant, water plays a crucial for its good growth.

The Malaysian Agriculture Research and Development Institute (MARDI) established in 1969. The institute main focuses are to strengthen the existing research to increase farmer incomes and increase yield. Several new rice varieties have been developed by MARDI. Currently MARDI has introduced new rice varieties MR 220 CL 1 and MR 220 CL 2 in order to overcome weed problems in rice field ecosystems. The main factor hinders the rice production is the high cost incurred to control weeds and weedy rice.

Weed;

When weedy rice populations invade an area, rice yield reduce to 55% and only 3.2 tons/ha. However the rice production can reduce to 74% when the weedy rice seriously infests an area. For example in 2004, it was estimated RM 88.9 million per season was wasted due to the weedy rice infestation. The Certified Production System (CPA) is a package rice production system solely introduced in order to overcome weedy rice problem.

The certified production system is utilized in order to combat the massive problems of weedy rice. The new rice variety imidazolinone tolerance (VT-IMI) is widely cultivated. The herbicide imidazolinone is used to control weedy rice without affecting the MR 220CL 1 and MR 220CL 2. The Deputy Agriculture and Agro based Industries Minister Datuk Johari Baharum said the hybrid variety came in two variants was the result of a collaborative effort with the German BASF company. The news was reported by Vinesh (2010).

Weedy rice is closely related to cultivated rice. It has caused a serious problem in direct-seeded rice in Asia. Dr.Azmi Man from MARDI and Dr.David Johnson from International Rice Research Institute (IRRI) have made a thorough study on weedy rice. They have stated three ways to prevent weedy rice from spreading to uncontaminated rice fields. First to avoid using rice seeds contaminated with weedy rice. Therefore farmers are encouraged to use clean seed from known source or certified seeds. Second, since rice seeds can be introduced by combine harvesters and tractors, therefore clean machinery to be used before going to the rice field. Finally water ways should be cleared of weedy rice seeds.

The establishment of the International Rice Year (IRY) was initiated in 1999. The main drivers were the International Rice Research Institute (IRRI) and the Food and Agriculture Organization of the United Nation (FAO). The theme for IRY was Rice is life is life. This theme is reflecting the importance of rice as a primary food source where more than half of the world's population.

Efficient and productive rice based farming systems are essential to economic development and improved quality of life particularly in relatively poor countries. Rice is mainly cultivated in 113 countries. It is grown in wide range of soil moisture regimes and different soil conditions ranging from deep flood to dry land. Therefore sustainable rice production requires genetic improvements for higher yield potential, better crop management techniques, reduced post-harvested losses and the development of integrated production system. Based on Sasson (2006) it requires training and information exchange and the transfer of safety-tested new technologies to the field.

Future;

Professor Sasson visited the Centre for Global Sustainable Study (CGSS) at Universiti Sains Malaysia (USM). His book on plant and agricultural biotechnology is a useful reference for future research work on rice. He discussed several scientific issues with members of CGSS. One of the main aims why CGSS was established was to have international connection in the area of sustainable development. Among the targets is to help in raising the living standard of rice farmers in Malaysia.

Apparently most of the rice farmers are comparatively poor. On the other hand, the centre is trying hard to push forward the concept of integrated biodiversity management to the rice agro ecosystem. The management concept is stressing on utilizing all rice field niches. For example for fish farming, duck rearing and livestock production. In addition, the vast rice field agro ecosystems could be used as roasting sites for migratory birds.

The scientific researches that could trigger the rice production particularly on crop breeding, genetic transformation, herbicide tolerance, biotic stress resistance and pest resistance. The scientific input on breeding quality rice from MARDI is considered to achieve its target. Cultivating field methods based on the efficient usage of the water supply adapting the ecological concept are studied at some local universities. The plant breeders are also trying to come out with a new hybrid that could use water efficiently. In addition, beta-carotene enriched rice is studied in order to overcome the vitamin A deficiency. The new hybrid is also known as golden rice is employed to overcome the vitamin A deficiency.

The key roles of CGSS are to serve as a forum for dialogue on creative new ideas, to serve as hub for the international community of scholar, to serve as a bridge between the national and international academic community, to work with the corporate sector and civil society and also policy makers. In addition, it is focus on the contribution for capacity building, particularly in Malaysia and the developing countries.

One of the focal points is to push forward for utilization of the biodiversity within the wet rice agro ecosystems based on sustainable development. Apparently rice agro ecosystem niches and its biodiversity should be enhanced for supplemented products. Improve farming system by promoting organic farming practices and usage of Satoyama Initiative for better rice field land use, are highly recommended. The Satoyama Initiative is based on the Japanese rice field system where water management is used efficiently for rice production. In addition the unique Subak hydrological systems that are widely practiced in Bali rice fields should be applied.

Conclusion;

Since rice production is an important food security for Malaysia, therefore the country has embarked in enhancing rice productions through various modern techniques. In this regard sustainable development is being widely practiced in order to safe guard the eroding of rice field biodiversity. Agro ecosystems such as rice fields are conserved for fishes and birds. The input from research organizations and universities has not only a strong impact on the increase of rice production in Malaysia, but also sustained the wet rice field landscapes. The picturesque rice landscapes are popular sites for eco tourism activity. Finally Malaysian rice agro ecosystems are allowed to adopt certain procedures in enhancing wetland biodiversity. As rice fields are considered as a wetland, therefore conservation of biodiversity based on resolution X.31 should be followed and adopted.

Acknowledgement;

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System of Rice Intensification (SRI) method; a boon for rice paddy farmers of Chilika Lake Basin, India.

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Abstract

Rice (*Oryza sativa* L.) is the basic diet of approximately 40% of the world's human population (Kundu & Ladha, 1999) and the traditional staple food in most parts of Asia. Agriculture, mainly paddy cultivation and related occupations, also provides the livelihood for a significant population of Asia. The Green Revolution focussed mainly on irrigated areas (Dobermann & White, 1999). However, in order to reach sustainable levels of rice production, the rain fed lowland areas must be developed as they possess the potentials of increasing future rice production (Dobermann & White, 1999). The rice paddy supports an amazing aquatic biodiversity. Sustainable development of aquatic biodiversity in rice-based ecosystems is essential to human well-being and to the livelihoods and cultural integrity of individuals and societies and thus plays a critical role in overall sustainable development and the eradication of poverty. In recent decades, an ever-increasing human population and related intensive farming practices, including a far greater dependence on chemical pesticide and fertilizer applications are exerting an increasing pressure on living aquatic resources. However the rice yields in irrigated rice areas in Asia have stopped increasing during the last decade and with a still rising human population the need for a corresponding increase in rice is seen as highly necessary (Tsujimoto et al., 2009). The System of Rice Intensification (SRI) method of rice cultivation has as its basis the potential for rice to produce more with less water and other inputs like insecticides and chemical fertilizer (Uphoff, 1999). In view of the looming crisis in water supply, increases in the use of insecticide and chemical fertilizer which threaten aquatic biodiversity, the depletion of soil fertility, and GHG emissions from traditional deep water cultivation, the SRI method of rice cultivation appears to be a better alternative and more environmentally compliant as it also relies on natural amendments such as compost and green manure. It also helps to address the issues of Biological Diversity Convention and Climate Change. This paper discusses the advantages of SRI methods of rice cultivation adopted by the farmers of Chilika Lake basin and its role to mitigate GHG emission and threats to aquatic biodiversity, while at the same time increasing soil quality through carbon sequestration.

Key words: Rice paddy, SRI, biodiversity, GHG, nutrition, livelihood

Introduction

The agro-biodiversity within the rice-based system presents great opportunities for improved nutrition within rural communities, increased farmer income through crop diversification, and the protection of a wealth of genetic resources for future generations. The System of Rice Intensification (SRI) was developed during the early 1980's in Madagascar as a low input system for resource poor farmers (Stoop *et al*., 2002). It differs from rain-fed traditional/conventional rice systems in several ways. The two main differences are; one is transplanting only very young seedling per hill and the second is the significant low water requirement thereby minimising the chances of GHG emission and increasing the level of the water table. SRI cultivation is a 'system' rather than a 'technology'. It is based on the insights that rice has the potential to produce more tillers and grain through early transplanting and optimal growth conditions (optimal spacing, humidity, biologically active and healthy aerobic soil conditions during vegetative phase) can fulfil this potential.

The "Green Revolution" was initiated few decades back to meet the growing demand of food. In order to achieve this, rice production has been intensified through Higher Yielding Varieties (HYV), chemical fertilizers and pesticides (Greenland, 1997). As a result, the world's production of rice doubled in the period between the 1960's and the 1980's (Tsujimoto *et al*., 2009). However the rice yields in irrigated rice areas in Asia have stopped increasing during the last decade and with a still increasing human population, the need for a ongoing increase is regarded as highly necessary (Tsujimoto *et al*., 2009). The Green Revolution focussed mainly on irrigated areas (Dobermann & White, 1999). However, in order to reach sustainable levels of rice production, the rain-fed lowland areas must be developed as they possess the potentials of increasing future rice production (Dobermann & White, 1999). It is expected that in order to feed a growing human population, yield increase of up to 70% are required from both irrigated and rain-fed lowland areas (Dobermann & White, 1999). Most of the rain-fed lowland areas are dominated by small scale farmers practicing various types of rice farming but all depending on rainfall and natural flooding (Stoop *et al*., 2002). They suffer from either partial or complete crop failure due to erratic rainfall. This may be further exacerbated by climate change events.

SRI system

The basic principal of SRI cultivation has been that rice plants do best when their roots grow large. In SRI, young seedlings are transplanted at shallow depth and at a wider spacing. The field is not flooded and soil is thereby kept well aerated which promotes a rich flora of diverse microorganisms. More precisely, SRI differs from normal flooded rice in i) transplanting of 8-10 day old seedlings, ii) wider spacing iii) reduced use of water by avoiding continuous submergence, iv) use of more compost and organic manures and v) reduced use of insecticide and pesticide. SRI has been claimed to result in significant increase in grain yield, saves water by 50% or more, as well saving on seed and fertilizer cost by using only a fraction of the quantity otherwise recommended. SRI is also regarded as a variety independent system. One of the important advantage of the SRI system is water saving. Independent studies in clay soil indicated a saving of 20-24% in irrigation water with intermittent flooding which improved the water use efficiency by 13-28% depending on season and nutrient management.

Saving on seed cost is evident from the fact that only 5 kg seed per hectare is used for SRI treatment as against 30-40 kg for normal transplanting. SRI does not require any specific seed or the use of new high-yielding varieties. Although the highest yields with SRI have been obtained from improved varieties, most traditional or local varieties of rice respond well to SRI practices and command a higher market price. Thus it addresses the issue of conservation of local genetic diversity. Though chemical fertilizer and agrochemicals can be applied in moderate quantity with SRI, their use is not required as organic materials (compost, manure or any decomposed vegetation) can produce good or even better results at a lower cost.

The farmers of Chilika Lake basin in India who have adopted SRI as an alternative to chemical insecticides and pesticides are using also organic solutions. While the chemical fertilizers and pesticides are easily available in the market, organic solutions are not readily available in the market. Yet promotion of these organic solutions for fertility and pest management would further reduce the costs in SRI. The farmers have started preparing these solutions collectively. Initially there were few difficulties in the preparation of these solutions by farmers individually. The SRI method also reduces the risk of nonpoint source pollution of the lake in form of fertilizer and insecticide pesticide run off from the paddy fields.

Farmers report that when SRI methods are used correctly, rice plants are better able to resist damage from pests and diseases, reducing or eliminating need for agrochemical protection. By reducing the application of agrochemicals in rice production, the resulting grain has little or no chemical residues and the hazard of handling agrochemicals by farmers is also eliminated. Preliminary studies on soil samples from farmer's fields showed substantial differences in soil microbiological, soil biological and soil chemical parameters under SRI system as compared with normal submerged cultivation. How critical are these factors in yield enhancement are being studied in collaborative studies with International Crops Research Institute for the Semi-Arid-Tropics (ICRISAT) India. Studies done by Ganesh et al. (2006) showed 25% higher grain yield when SRI was adopted for seed production purpose. They also reported that SRI method reduced the duration for crop maturity by six days.

The small and marginal farmers have problems of land, resources in form of inputs like seeds, water, fertilizer which affects production cost, sales and profit. Many farmers all over Asia have already identified low-input, sustainable solutions to the problem. SRI is a simple method that boosts the rice yield with low input. Resource poor farmers (RPF) who cannot afford to invest in chemical fertilizers rely on natural amendments such as compost and green manure. Applying plant residues in several forms will not only benefit soils but also address the issue of GHG emissions.

When SRI paddy is milled, the quality of output is often higher, as there are fewer unfilled grains (less chaff) and fewer broken grains (because they resist shattering). Farmers are finding that SRI methods often, though not always, reduce the time required for grain maturation. Being able to harvest sooner reduces farmers' risks of damage from pests or from typhoons, cyclones or other extreme weather that could come at the end of the season. No systematic nutritional analyses have been done yet on SRI grains, but the larger root systems could enhance their micronutrient content, suggested by the higher grain weight and greater resistance to shattering.

Rice Paddy and GHG

Rice is generally considered as a water intensive crop that emits "greenhouse gases" due to flooding. In the tropics, farming and global warming might go hand in hand, as rice production can be considered a future threat by further contributing to global warming. The reduced need for water in the SRI method addresses this issue. Un-flooded paddies do not produce methane, one of the major "greenhouse gases" associated with rice paddies. It also frees up water for other uses; soil that is not kept saturated also has greater biodiversity. However there can be more nitrous oxide from un-flooded paddies, which offsets to some extent the gains from reducing methane emissions, but when nitrogen fertilizer is not used, this effect could be minimised. Thus the SRI method is potentially more environmentally friendly in some areas when compared to more traditional methods of rice paddy culture.

SRI and Convention of Biological Diversity

SRI addresses some of the issues relevant to CBD strategic plan 2010-2020, which are as follows:
Strategic goal C- i.e. safeguards ecosystems, species and genetic diversity.
Target 13: *to achieve improvement in the status of crop genetic diversity in agricultural ecosystems and wild relatives*.

Strategic Goal D- to enhance the benefits from biodiversity and ecosystems.
Target 14: *safeguard, restore, and adequate equitable access to essential ecosystem services is guaranteed for all, especially for indigenous and local communities*.
Target 18: the *traditional knowledge, innovations and practices are protected and their contribution to the conservation and sustainable management of biodiversity is recognized and enhanced*.
Target 19: *knowledge and technologies relating to biodiversity, its value and functioning, its status and trends, and the consequences of its loss, are improved and widely shared.*

Limitations

The System of Rice Intensification (SRI) developed in Madagascar has been controversial in some agronomic circles in part because there have been no large-scale, long-term evaluations of the impact of the methods so far. Due to non-flooding the weed growth is greater which requires extra effort for control. The effectiveness of the organic and biological control of insects and pest in long run also needs to be evaluated.

Conclusion

SRI has the benefit of being particularly accessible for farmers who have small landholdings and need to get the highest yields possible from their available land. The low input and water requirement and high yield coupled with, enhanced soil microbial diversity is a great advantage. Since poorer households have relatively more working hands available compared to land, SRI is one of the few agricultural innovations that have a bias in favour of equity. It is true that very poor households may find it difficult to invest labour in SRI because they need to be earning daily incomes, even if their returns to labour would be higher from SRI. SRI methods are most productive when used with skill and care. However, SRI should be seen as a set of principles that are applied through various techniques, rather than as a fixed technology to be adopted as a "package." It is anticipated that various kinds of mechanization will over time make SRI suitable for larger scale production as well. In a world with a growing population and risks of food shortages, SRI can provide security for the poorest groups and it should therefore receive more attention in the future regarding research. It may be concluded that SRI is a promising management practice which is climate compliant, farmers friendly and facilitates biodiversity conservation. SRI could be included in the national strategy for poverty reduction. The governments of China, India, Cambodia, Indonesia, and Vietnam are already encouraging the adoption of SRI.

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Rice Production and a Vision for Mekong's Wetlands

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Key words: paddy field, wetland, climate change, ecosystem, ecological function, biodiversity, Mekong vision

In last 25 years, in the light of '*doi moi*' (reforms) era, Vietnam has changed from a country of food-shortage to one of the world's leading rice exporters. Rice field is the predominant land use in Vietnam and is concentrated in the two of the country's largest delta areas: Red River Delta in the North and Mekong Delta in South. Of them, the Mekong Delta of Vietnam is the country largest area for rice production and now accounts for over half of the nation's rice. The area is therefore of prime importance to Vietnam's economy, and supports one of the highest human population densities of anywhere on earth. The delta also has a large area of *Melaleuca* forest, seasonally inundated grassland and swamp, mangrove, mudflats and aquaculture ponds, and interconnecting river channels and canals. This diversity of habitats gives the delta considerable biodiversity importance as well as ecological values which are often overlooked.

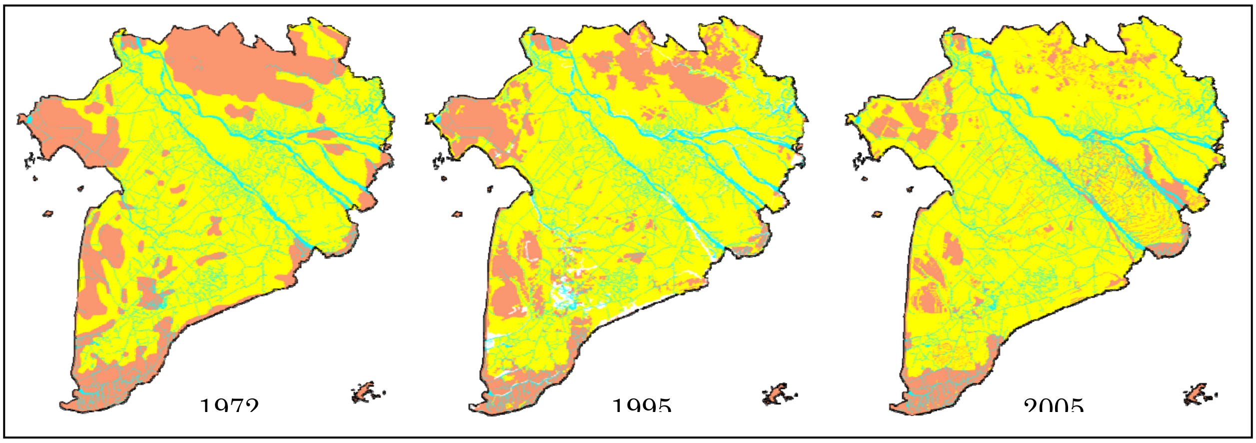
Mekong Delta, Vietnam

The Mekong Delta, Vietnam (Cuu Long [or Nine-Dragons in Vietnamese] Delta (hereafter call "the delta") implies the part of downstream area of the Lower Mekong Basin is 40,602 km^2 in area, inhabited almost 17,7 million of people. With a total of c. 1.7 million hectare of rice field, the delta produces c. 20 million tones of rice per annum (Vietnam Statistic 2009). Beside the importance as a rice bowl of the nation, the delta supplies more than 65% of fish and 70% of fruit for the country (Le Anh Tuan 2009)[13].

Rice production in the delta

For centuries, Mekong Delta was already an important area for agricultural production in Vietnam.

[13] Le Anh Tuan (2009) Agriculture, Rice Production and Climate Change: Methods and Lessons from the Mekong River Delta, Vietnam. Ppresentation at the Mekong Delta Climate Change Forum: Can Tho City, Vietnam, 12 - 13 November 2009.



Map1: Agricultural area in Mekong Delta in 1972, 1995 and 2005 (yellow= rice)

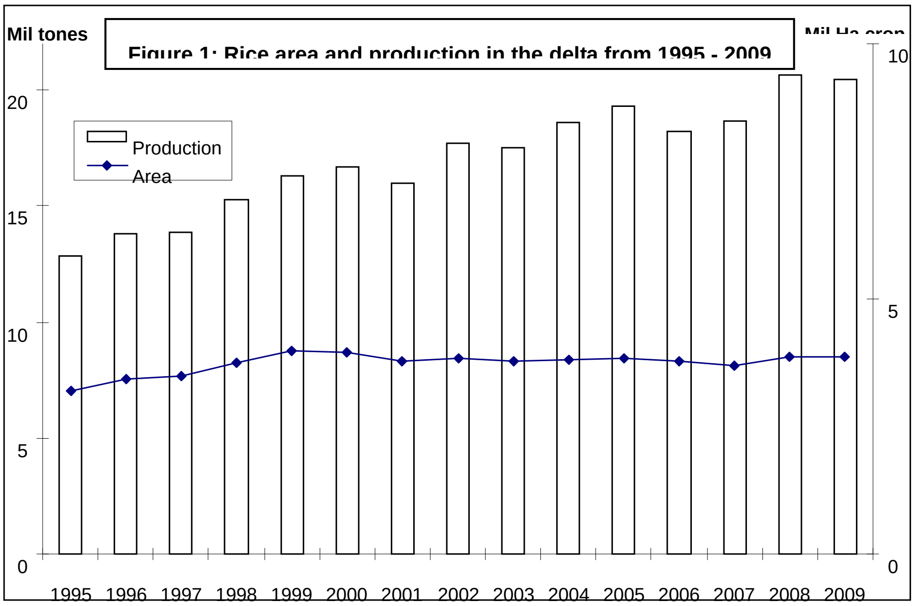
Before the reunification day (1975), the delta was already dominated by paddy fields. According to Vo Tong Xuan (1975)[14], in early 1970s, the delta accounted for 70% of (south[15]) nation's rice land and provide c. 73% (or c. 2.8 million tones) of the rice production (Map 1). Though generations, delta's famers have developed a wide range of cultivation practices that suit and are well- adapted with the environmental conditions and their traditional means. The rice production techniques have been developed to make use of various hydrological regimes under the influences of regional climate and Mekong River flows. Three most common rice cultivation systems are: floating rice in the low lying flood-plains, two-crop rice in the inland areas, and one-crop rice in elevated and coastal areas. Traditional rice yields at the time were averaged to 1 – 2.5 t/ha. Since 1968, high yield variety (HYV) rice was introduce, and at 1970s, there were some 800,000 ha, or roughly 27% of delta's total rice area (Vo Tong Xuan, 1975). The traditional extensive systems do not rely on the use of chemicals and machinery. This allows the rice fields to support a high stock of fresh water fish, as well as other biodiversity.

The delta had observed a quiet time from 1975 to mid 1980s. In 1986, the government of Vietnam initiated a reform policy that encouraged a significant change in rice production in the country. The rice and shrimp production in the delta increased markedly during last 25 years. According to the statistic data, the total rice production increased to 12.8 million tones in 1995 and made 1.5 fold to 19.2 in 2005 and 20.48 million tones (Figure 1, Vietnam Statistic 2009). This rapid increase required a massive land conversion in late 1980s that tried to make use of all "waste" land in the delta. In these years, large areas of natural and semi-natural habitats were removed. The battle between rice and shrimp was also observed

[14] Vo Tong Xuan (1975) Rice Cultivation in the Mekong Delta. *South East Asian Studies* Vol 13(**1**) 1975. pp 88-111.

[15] From 1954 to 1975, Vietnam was divided into two nations, Republic of Vietnam in the South and People's Republic of Vietnam in the North.

that made the inter-changes between two landuse types. In late 1980s and early 1990s, a huge flush of land conversion for shrimp ponds and many of the rice areas were also subjected. Mid 1990s, while a large area of shrimp ponds was abandoned, some of them were reconverted to rice-fields.



To increase rice production, in the delta, beside land conversion, intensification was encouraged. In the first years of the '*doi moi*' era, the use of fertilizer, pesticide, herbicide, and fungicide increased dramatically. This use was only reduced with the introduction of integrated pest management (IPM) schemes in mid 1990s (Berg 2001[16]). To intensify rice production and reduce the risks from floods, a large investment was made on hard development including the well developed dike and channel systems. Moreover, during the last decades, the delta has suffered more threats from upstream development and climate change. Upstream dams and land conversion have led to reduction of silt and nutrients, and change of water and flow regimes. Couple with impacts from climate change, they caused severe salinity instruction and increased the frequency and severity of natural disasters. Flood once was considered as an "enemy" for the economic development in the delta. Therefore, approximate US$ 4 billion has been spent over the last twenty years on flood control that caused remarkably change in the delta's hydrology, and to late 2000s, their was no big flood and the delta experienced years of no water (Duong Van Ni 2005)[17]. Rice intensification was considered as a severe threat to the biodiversity in forms of loss traditional practices and crop varieties, as well as, reduction of other biodiversity, especially

[16] Berg, H. (2001) Pesticide use in rice and rice–fish farms in the Mekong Delta, Vietnam. *Crop Protection* 20 (2001), pp. 897–905.
[17] Duong Van Ni (2005) The Role and Function of Wetlands in the Mekong Basin. Presentation at the Mekong Water Dialogue Workshop, Vientiane, Laos.

the aquatic taxa, in the intensive rice paddies. Furthermore, most of the potential ecosystem services that the traditional rice paddies provided are no longer available. Those services include least but not last the flood mitigation (by water storage and discharge, and sediment accumulation), water regulation, local climate moderation and provision of plant and animal food resources and medicinal plants etc..

A vision for the delta

Current practice of rice production in delta, couple with inappropriate developments up- and down-streams and climate change, however, affect the key ecological functions of paddy field, namely, flood mitigation, nurturing aquatic ecosystem, and maintaining agro-ecosystems biodiversity. To response to this challenge, consensus vision for the development Mekong Delta is required. The vision needs to integrate national development priorities, climate change scenarios, and wetland use options that can strengthen resilience to climate change while provides important co-benefits in terms of livelihoods and biodiversity. An ecosystem-based adaptation approach, that will invest more in ecosystems (e.g. crop diversification, integrated pest management, or application of multi-use approaches such as rice-fish, rice-shrimp production, opposed to more dykes, canals, and other “hard” measure), needs to be adopted to maintain and increase the resilience and reduce the vulnerability of delta’s ecosystems and people in the face of the adverse effects of climate change.

Making Rice Paddy Compatible with Wetland Conservation Objective[18]

Bishnu B. Bhandari[19]

Abstract:

The overall objective of the paper is to make rice paddies compatible with the objectives of wetland conservation in Nepal so that rice cultivation simultaneously meets a two-pronged objective by i) increasing its production to reduce poverty and ii) enhancing its biodiversity as wetland system. Rice fields and paddies are synonymous. Rice that is grown in rice fields is "*life for almost half the planet's population*". According to the Ramsar's Classification System for Wetland Type, rice paddies are one of the types of wetlands under the category of human-made wetlands. Rice paddies provide important ecosystem functions such as serving as an important source of nutrition to billions of people all over the world, major source of income and employment for the poor. They are biologically important because it provides habitat for reptiles, amphibians, fish, crustaceans, insects and mollusks as well as stopover for migratory waterfowl. They also support the ecosystems through the protection of soil from erosion and water-induced disaster.

The second half of the paper discusses rice cultivation at the highest altitude of 3,150m in Nepal. Major issues such as rice needing some 3,000 liters of water to produce just one kg of rice, problems caused by the extinction of traditional varieties and striking a balance between raising productivity and conservation are also discussed. Finally the paper explores some research issues that need to be taken up by all to promote the Ramsar Resolution X: 31 "*Enhancing biodiversity in rice paddies as wetland systems*".

Introduction

The overall objective of the paper is to make rice paddies compatible with the objectives of wetland conservation so that paddy simultaneously meets the two-pronged objective i) of increasing rice production and ii) enhancing its biodiversity as a wetland system. It also suggests some ways to promote the maintenance and enhancement of the ecological and cultural roles and values of appropriate rice paddies.

1. Rice is life for about half the World's population

Rice is the staple food for over 50% population of the world and 90% of Asia (**Basnet, circa. 2008)**. It is mostly grown in the paddies of Asia. Paddy is a common agricultural landscape

[18] Paper presented at the *International Workshop on Rice Paddy and Wetland Conservation*, Takashima City, Shiga Prefecture, Japan; 6-7 August 2010.

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that protects soil from erosion and use waters efficiently. It is the source of livelihoods for billions of people in Asia and provides them with vital nutrition. Therefore, rice is life for about half the world's population.

In rural areas, rice is the primary source of income for the people and its cultivation provides opportunities for their local employment as most of the countries in the developing counties are agriculture based in general and rice based in particular (**Tsuji 2006; Rajaure, 2006; Viseth et al., 2006)**) .

Paddy is an important field for rice production and controls two important variables – arable land and water, both precious assets and thereby heading towards scarcity.

2. Paddy is an important biological ecosystem

Paddy provide varieties of ecosystem services such as provisioning (water, rice, fish and other crops on its bonds and ridges), regulating (water storage, recharge and recharge of waters, purification and mitigation of water-induced disaster), rice-based culture (cultural practice of rice cultivation, mud-splashing, festival celebrating the rice planting events, paddy dance or transplantation festivals) and supporting services. In one study iCOOP (**nd**) recorded some 51 species in the rice fields in rice paddies and its waterways just after planting rice. It is evidence that rice farming does not lead to disturbing the ecosystem. This is possible only with clean water and without fertilizers and chemicals (**Kurechi, 2006**).

Paddies are biologically important because they provide habitats for various kinds of living beings such as reptiles, amphibians, fish, crustaceans, insects and mollusks (**Ramsar Convention, 2008**). According to the Ramsar Resolution X.31 "*Enhancing biodiversity in rice paddies as wetland ecosystem rice paddies*" rice paddy also serves as the stop-over for migratory birds on their flyways and thereby supporting the conservation of migratory water birds (**Ramasar Convention, 2008**). The huge expanse of paddy field in Nepal's Terai serves as a foraging ground for Sarus cranes, egret, geese, stork, as well as other migratory birds. Egrets, frogs and spiders eat harmful insects and they serve as a biological control. Demoiselle Cranes, small species of the Crane, which breed in Mongolia, northern China and south-east Russia cross the Himalayas to the Indian sub-continent and stop over a few days in Nepal from September to October. They fly about 300 km/day and travel some 3000-4000 km. During their stop over, they use rice fields and floodplains of western Nepal's Kailali and Kanchanpur districts.

Because of terraces, paddy protects landscape from soil erosion and helps use water efficiently. Therefore, the practice of paddy cultivation is a practice which assists in environmental conservation.

3. Paddy is a human-made wetland ecosystem

The Ramsar Convention, while commonly known for designating Ramsar sites, also maintains the list of Wetlands of International Importance, commonly known as the Ramsar sites list. For this purpose, it has prescribed a classification system called "*Classification System for Wetland Types*". The system was approved by the Ramsar *Recommendation 4.7: Mechanism for improved application of the Ramsar Convention* of the 4th Meeting of the Conference of the Contracting Parties (COP) in 1990. The recommendation was subsequently amended by *Resolutions VI.5: Establishment of a Scientific and Technical Review Panel* and VII.11: *New Bureau headquarters in Switzerland* of the 5th COP in 1993 (**Ramsar Convention Secretariat, 2006:63**).

The wetland classification system needs to be applied while collecting data and information for the Ramsar Information Sheet (RIS). The classification is useful to rank the sites in order of their predominance. The classification also provides a broad framework of wetlands under three categories; **(i) Marine/Coastal Wetlands, (ii) Inland Wetlands** and **(iii) Human-made Wetlands**. Some 42 types have been grouped under these three categories (**Ramsar Convention Secretariat, 2006:17**). The categories listed in the classification were not intended to be scientifically exhaustive, but only to provide a broad framework for the rapid identification of the main wetland habitat type represented at each type.

Paddy is therefore a human-made wetland and falls under the irrigated land which includes irrigation channel, irrigated or flooded rice fields (**Ramsar Convention Secretariat, 2006:64**). According to Resolution X.31, *rice paddies are the flooded and irrigated fields in which rice is grown*. Big rivers (Ganges, Indus, Mekong and Yangtze) are closely associated with large rice paddies.

The primary intention of the Resolution X.31 is to affirm the role of paddy in maintenance and enhancement of ecological and cultural values of both rice paddies as well as wetland systems, consistent and in harmony with the Convention, the internationally agreed development goals and other relevant international obligations. This resolution is not to be used to justify conversion of existing natural wetlands into human-made wetlands or to justify inappropriate conversion of land to human-made wetlands (**Ramsar Convention, 2008**).

4. Rice paddy in Nepal

Rice is not only a staple food in Nepal but also a crop with religious and prestigious values. The husked rice grains are considered sacred and offered to deities. These grains are considered as auspicious symbols. Paddy is also socially regarded as the prestigious crops. In all kind of feasts, rice occupies an important place. In some district such as in Jumla, people look down upon those who do not grow rice in their fields.

According to Baidhya (**2066**), Nepal has the record of cultivating rice at the highest altitude of 3050m at Chhumjyu in Jumla district. The variety comes under the group of *Japonica* species. The species is grown in an original way such as soaking the seeds on 26 March (12 Chaitra, Nepali calendar), draining seeds in 30 March (16 Chitra,) and then broadcasting the sprouted seeds in the nursery bed on 3 April (20 Chaitra) (Baidhya, 2065vs). After about 6-8 weeks later, they transplant the seedlings into the field with many festivities. The first harvest of the crops is offered to Baba Chandan, who is believed to have introduced rice in the region.

The World Paddy Day is celebrated all over the world in 29 June. It is celebrated as a National Paddy Day in Nepal as well. It is an excellent event to raise awareness about the importance of rice to life on a global scale. The event also refreshes our memory and renders a platform to spearhead new initiative or promote existing activitiesSome living organisms are the harbinger of prosperity and happiness: for example, poong-nyun (small shrimps) in rice fields in Korea, sarus crane foraging in the rice fields in Nepal's rice fields, and the coming of the Black-headed Crane in Vietnam are all seen as a harbinger of happiness and prosperity.

Challenging Issues

- **Growing water scarcity & needing more water**: One kg of rice production requires 3,000 liters (3 thousand) of water and in one hectare of land needs about 800,000 liters (800 thousand) of water (**Basnet, circa 2008**). The basic issue is how to make the growing scarcity of water and the huge requirement of rice cultivation compatible.

- **Poverty reduction vs. conservation**: Th eworld's almost 2.8 billion population lives on $2 a day. About 1.4 billion people (1 in 4 people) live on less than US $ 1.25 a day. Therefore our main concern is to reduce this poverty. On the other hand, we need to conserve rice as a wetland ecosystem for their ecological and cultural functions. That is why there is a growing tendency to convert wetlands into rice fields. The issue before us is to strike a balance between poverty reduction and conservation of paddy as a wetland ecosystem and find out ways to replace the inappropriate agricultural practices.

- **Contradiction between paddy conservation and producing more**: Likewise, there is a contradiction between paddy conservation and producing a greater yield of rice. We need to explore the way to build a synergybetween production and conservation.

Enhancing biodiversity in rice fields: The following actions are suggested to enhance biodiversity in rice fields:

- *Promoting organic rice culture*: Organic rice culture such as no or less use of fertilizers and insecticides, protection of traditional varieties, keeping the land fallow, adoption of water efficient rice varieties, zero tillage practices, cropping on bonds should be followed.
- *Learn from the Ruoergai's eco-tourism program*: In Ruoergai of the Tibet Plateau eco-tourism has been successful to reduce the pressures of herd on the local environment by providing new livelihood opportunities to local herd communities. Reducing the size of the herd has been successful to increase the quality and quantity of meat production of yaks in the region. *Learn from Korea's biodiversity contract program*: In Junam, South Korea, local farmers are provided with incentives to grow barley as food for migratory birds visiting the area. The biodiversity program has provided guarantee to the famers as a source of cash income as well as opened up new opportunities for developing tourism-based local industries in the area.

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Rice paddy as a Climate Change Adaptation option in the wetlands of Bangladesh

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Introduction

The society and civilization of human beings are about eight thousand years old. We have observed great changes in religion, dress, habitat as well as culture but without any significant ones in food habits. For example, rice or paddy still occupies a great part in our life style as a means of satiating hunger. Paddy is the oldest staple crop in Bangladesh and still regarded as the principal food of the people here. About 65% of land area of Bangladesh is subject to flooding of different depth and duration. There are types of wetland in Bangladesh; Haor and beels are special types of wetland found in Bangladesh.

Haor is bowl-shaped large tectonic depression. It receives surface runoff water by rivers and canals, and consequently, a haor becomes very extensive water body in the monsoon and dries up mostly in the post-monsoon period. In Bangladesh haors are found mainly in north eastern part. During monsoon a haor is a vast stretch of turbulent water. In its original form, the haor basin comprising the floodplains of the Meghna tributaries would have consisted of a rich mosaic of permanent and seasonal lakes and ponds with abundant aquatic vegetation.

Beel a large surface water body that accumulates surface runoff water through internal drainage channels; these depressions are mostly topographic lows produced by erosions and are seen all over Bangladesh but more dense in the south western part of the country. Beels are small saucer-like depressions of a marshy character. Many of the beels dry up in the winter but during the rains expand into broad and shallow sheets of water, which may be described as fresh water lagoons. Haor and beel are prime paddy cultivation ecosystems of the country in most cases they are mono-cropper land and the rice paddy is the crop.

Rice paddy of Bangladesh

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1. President, Bangladesh POUSH

In Bangladesh most of the rice paddy grown in low-lying areas during the monsoon season is floating type, locally known as *jolidhan*, *poushdhan*. Those rice varieties grown in more than 50 cm water for one month or a longer period during the growing season. The traditional tall cultivars have long leaves, and are grown at water depths of between 50 and 100 cm; floating rice is grown in 100 cm or deeper. Deepwater rice grows under rain fed dry land condition for 2-4 months, before the onset of flood, when the plant produces basal tillers. With inundation, the plant becomes an emergent macrophyte and grows in an aquatic environment for the remaining 3-5 months of its life. There is an increase in the number of elongated internodes with the increase in water depths. Majority of deepwater rice cultivars in Bangladesh is of strong elongators. Stems may reach 5-6 m in very deepwater (3-4m) situations.

Deepwater rice is usually dry seeded in the months of March-April following the first monsoon shower. In some areas, farmers establish deepwater rice by transplanting seedlings following the cultivation of dry season rice. Very little fertilizer is used and weeds are effectively controlled by harrowing and hand weeding, twice before flooding occurs. In haor use of fertilize is negligible in comparing with the beel areas. Crops mature between mid-October and mid-December, depending on the degree of photo-period sensitivity of the cultivar. Grain production tends to increase with the increase in biomass up to 12m tons/ha (dry weight). Deep water rice, cultivated on 2.5 million hectors area which is 24% of the total rice area of Bangladesh.

Changes in climate parameters

The country enjoys a humid, warm, tropical climate. Its climate is influenced primarily by monsoon and partly by pre-monsoon and post-monsoon circulations. The south-west monsoon originates over the Indian Ocean and carries warm, moist, and unstable air. The monsoon has its onset during the first week of June and withdraws in the first week of October; however, the onset and withdrawal dates vary from year to year. The main rainy period begins with the onset of the moisture-laden south-west trades which are drawn to the Indian sub-continent by the intense heat and consequent low pressure over Punjab (in Pakistan and India) and the Upper Ganges Valley and the filling up of the equatorial lows by air masses from these hot areas.

Besides monsoon, the easterly trade winds are also active, providing warm and relatively drier circulation. In Bangladesh there are four prominent seasons, namely, winter (December to February), Pre-monsoon (March to May), Monsoon (June to early-October), Post-monsoon (late-October to November). The general characteristics of the seasons are as follows:

- Winter is relatively cooler and drier, with the average temperature ranging from a minimum of 7.2 to 12.8°C to a maximum of 23.9 to 31.1°C. The minimum occasionally falls below 5oC in the north though frost is extremely rare. There is a south to north thermal gradient in winter mean temperature; generally the southern districts are 5oC warmer than the northern districts.
- Pre-monsoon is rather hot with an average maximum of 36.7°C, predominantly in the west for up to 10 days, very high rate of evaporation, and erratic but occasional heavy rainfall from March to June. In some places the temperature occasionally rises up to 40.6°C or more. The peak of the maximum temperatures are observed in April, the beginning of pre-monsoon season. In pre-monsoon season the mean temperature gradient is oriented in southwest to northeast direction with the warmer zone in the southwest and the cooler zone in the northeast.
- Monsoon is both hot and humid, brings heavy torrential rainfall throughout the season. About four-fifths of the mean annual rainfall occurring during monsoon. The mean monsoon temperatures are higher in the western districts compared to that for the eastern districts. Warm conditions generally prevail throughout the season, although cooler days are also observed during and following heavy downpours.
- Post-monsoon is a short-living season characterized by withdrawal of rainfall and gradual lowering of night-time minimum temperature.

According to IPCC in their recently published Fourth Assessment, the following changes have been observed in climate trends, variability and extreme events in Bangladesh:

- In Bangladesh, average temperature has registered an increasing trend of about 1°C in May and 0.5°C in November during the 14 year period from1985 to 1998.
- The annual mean rainfall exhibits increasing trends in Bangladesh. Decadal rain anomalies are above long term averages since 1960s.
- Serious and recurring floods have taken place during 2002, 2003 & 2004.
- Cyclones originating from the Bay of Bengal have been noted to decrease since 1970 but the intensity has increased.
- Frequency of monsoon depressions and cyclones formation in Bay of Bengal has increased.
- Water shortages has been attributed to rapid urbanization and industrialization, population growth and inefficient water use, which are aggravated by changing climate and its adverse impacts on demand, supply and water quality.
- Salt water from the Bay of Bengal is reported to have penetrated 100 km or more inland along tributary channels during the dry season.

- The precipitation decline and droughts has resulted in the drying up of wetlands and severe degradation of ecosystems.

Impact of climate change on agriculture of Bangladesh

Flood: Four main types of natural floods occur in Bangladesh: flash floods, river floods, rainwater floods, and coastal floods induced by storm surges. Flooding usually begins in flashy rivers in the hilly areas during the pre-monsoon months of April and May. These flash floods take place suddenly and last for a few hours to a couple of days. Run-off during exceptionally heavy rainfall occurring in neighboring upland areas is responsible for flash floods. Such floods occur as waters from the hilly upstream rush to the plains with high velocity, mauling standing crops and destroying physical infrastructure. They occur most frequently - sometimes several times a year - at the foot of the northern and eastern hills of Bangladesh. Flash floods cause extensive damages to crops and property, particularly in the haor areas. For crops, it is their timing which is usually most important. Early floods (in April-May) generally cause severe damages.

Table 1: Flash flood damage of rice in haors of Sunamganj district:

Year	Flood water entered the *haor*	Inundating the *boro* crops	Extent of damage	Damaged *boro* crop in hector	Cost of damaged crops in Lac taka
1996	16 March	18 March	75%	29,822	4,102.07
1997	22 May	24 May	15%	9,830	1,278.84
1998	20 May	23 May	40%	11,579	2,365.02
1999	03 May	06 May	45%	10,950	976.65
2000	28 April	30 April	70%	1,355	420.14
2001	27 April	30 April	75%	4,963	1,899.95
2002	14 April	18 April	70 %	21,677	7,058.16
2003	27 May	30 May	20%	20,997	8,666.87
2004	13 April	15 April	90 %	95,402	34,860.40
2005	22 May	25 May	15%	-	-

Around 4000 sq. km area of south-east and 1400 km area of north-east Bangladesh are subject to flash flood.

The frequency of reverie flood in Bangladesh has been increased. Earlier the interval between two major floods was around 10 years, but currently it comes to 2 to 3 years. There are examples of two-spell flood in a year. In 2007 there were two-spell damaging the rice for whole the seedling season; the flooding status of the Jadukanta river was as follows in 2007.

Figure 1: River Gauge Level (m) of Jadukata River for the year 2007

River bank erosion: Most of the rivers of Bangladesh flow through unconsolidated sediments of the Ganges-Brahmaputra-Meghna floodplain and delta. The riverbanks are susceptible to erosion by river current and wave action. River erosion includes channel shifting, the creation of new channels during floods, bank slumping due to undercutting, and local scour from turbulence caused by obstruction. The Brahmaputra, the Ganges, the Meghna, the Teesta, and the Surma-Kushiyara rivers flow within well defined meander belts on extensive floodplains where erosion is heavy. Sudden changes are common during floods that cause rapid bank erosion. In lower deltaic areas, river bank erosion is caused by tidal currents and storm surges from the sea. The Bangladesh Water Development Board (BWDB) estimated that about 1,200 kilometers of riverbank has been actively eroded and more than 500 kilometers has been facing severe problems related to erosion. Satellite-image studies of the Ganges-Brahmaputra-Middle-Meghna rivers show that an area of 106,300 hectares has been lost due to erosion between 1982 and 1992, while the accretion amounted to only 19,300 hectares. The net erosion rate was therefore estimated at 8,700 hectares per annum.

Drought: In terms of magnitude drought exhibit a pronounced spatial distribution in Bangladesh. The western parts of the country receive less rainfall averaging some 1400 mm as against the national average of about 2150 mm. As a consequence, susceptibility and severity of drought in the western districts are much higher than elsewhere. Based on the characteristics of moisture retention capacity, infiltration etc. high prevalence of drought is observed in the western districts of Rajshahi, Bogra, Pabna, Dinajpur, Rangpur and Kustia.

There were very severe droughts hit the country in 1951, 1961, 1975, 1979, 1981, 1982, 1984, 1989, and 1995. It is claimed that as high as 47% area of the country is drought vulnerable where 53% of current population live. The drought that occurred during 1978-79 took a huge toll. In 1995 drought occurred during the late rainy season and caused a net reduction of 377,000 tones of rice production.

Salinity Ingress: Ingress of salinity is a major problem in coastal Bangladesh. Diminished flow in the dry season allows salinity to penetrate far inland through this estuarine river system. Salinity limits opportunities for supplemental irrigation of rice crops in freshwater areas and damages the same crops by flooding during very high tides. The upland progression of saline water during the dry season eliminated surface water potentials for significant land areas in the southwest, south-central and southeast regions. Because of sea level rise around 120000 squire kilometer area of Bangladesh is vulnerable to flooding.

Changes in Temperature: Changes in temperature have a serious impact on the crop physiology. In 2007 the temperature in winter goes down in the Haor basin. May be it was bellow 18 that cause no cereal in the rice.

Potential of rice paddy

As the frequency of flood has increased because of the climate change rice paddy may have a potential. A wide area of Bangladesh goes under water during monsoon; if rice paddy is cultivated there will be less risk of crop loss. The three best yielding cultivars of deepwater rice in Bangladesh are Pankaich, Khama and Kartik Sail with and yield exceeding 3 ton/ha some time in 2.5 meter of water.

Lam Dhan was very popular rice paddy of Haor basin in Bangladesh though it is not currently cultivated. The framers used the leaf as fodder for their cattle also. It was possible to harvest green leaf for 3 times.

Deepwater rich varieties of Bangladesh are remarkably versatile. Although normally growing in water from 50-350 cm deep, it will also produce a reasonable yield on moist unflooed soil and is tolerant of drought in the young stage of growth. It can be broadcast, dibbled or transplanted at various seedling stages.

Conclusion

The Government of Bangladesh considers climate change as a development concern and is committed to take urgent and long term actions to reduce the vulnerability of its people and risks to national development. The PRSP (2005) of Bangladesh outlines a comprehensive medium-term strategy in a sound macroeconomic environment for implementing pro-poor growth, effective safety-net programmes and human develop. The PRSP -II formulation process has just began where Climate Risk Management and Adaptation is being considered as a development agenda. Crop agriculture in Bangladesh is highly susceptible to variations in the climate system. Despite being highly vulnerable, very little efforts have so far been made to understand potential of agricultural adaptation in Bangladesh. Rice paddy cultivation could be an adaptation option because of the flood tolerant capacity. The selection of potential varieties and researches for the development of rice paddy is indispensable.

Sustainable Rice Paddy for Floodplain Ecosystem Conservation under Emerging Climate Change: Case of Bangladesh

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Bangladesh is one of the most climate vulnerable deltaic countries in Asia with the globally highest rural population density. The country is getting prepared with strategic climate resilient development initiatives including wetland and river restoration which focus on food security, ecosystem services, and climate induced water risk reduction and adaptation to meet the challenge. IPCC findings[22] include: crop yields could increase by 20% in East and Southeast Asia, but decrease by up to 30% in Central and South Asia. Bangladesh's climate, land and hydrology make conditions suitable for growing tropical rice paddy varieties which occupies about 80 percent of the cropped area[23].

Wetland conservation is getting more policy, planning and budget attention as rice paddy is the most climate adaptable food crop which grows along with fish and aquatic resources. This is one of the reasons why population density is comparatively higher in the floodplains as it offers multipurpose livelihood support. The impact of climate change on rice paddy based agricultural practices and its relation to water resources are of particular concern in the floodplain ecosystem in Bangladesh. There are five main kinds of floodplains in Bangladesh such as (1) Active River floodplains – alongside the main rivers with the youngest alluvial land, (2) Meander floodplains – relatively older, (3) Piedmont Plains – gently sloping land at the foot of hills, (4) Estuarine floodplain- smooth and level land with deep silt deposition and (5) Tidal floodplains- close to sea – almost level by clay plains crossed by tidal rivers. Impact of climate change and variability on rice paddy are found to vary over place and time, particularly related to location and type of flood plains.

The crop calendar in Bangladesh is synchronized with climatic seasons and agro-ecological settings, including land types. Rain-fed agriculture in particular is adversely experiencing erratic monsoon rainfall, affecting both local ecosystems and cropping patterns. Loss of biodiversity will have additional negative effects on people's lives and livelihoods alike. Agricultural adaptation emerged as a high priority for ensuring food security in a changing climate. Introduction, dissemination and extension of flood, salinity, and drought and diseases resistant rice crops variety are some of them. Adoption of early mature and short rotation crop, extension of hydroponics or floating agriculture in flooding areas can reduce

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[22] IPCC 2007. *Climate Change 2007*, Fourth Assessment Report. Accessed on 14 April 2008 at http://www.ipcc.ch/ipccreports/assessments-reports.htm

[23] Hugh Brammer. 2002: Land Use and Land Use Planning in Bangladesh, UPL, Dhaka, p.16

the climate risk and vulnerabilities in these sectors. Improvement in the crop-based weather and flood forecasting systems is some of the adaptation measures that would also be urgently required. Important wetlands and floodplains should be declared protected. Ecological services of wetland and environmental goods such as clean water, flood water reservoir and protection, recharge of depleted ground water, healthy soil, wildlife habitats, micro-organisms, and biodiversity are not appreciated by mainstream agricultural science and civil engineers. In the short run, this science has proved to be enormously successful in increasing food production in those low-income countries that have benefited from the agricultural production technologies of the Green Revolution. However, the long-term damage to the environment and human health that has resulted from this success is now being revealed: arsenic water contamination in ground water, mono-culture and land degradation as well as water pollution. Wetland conservation for enhancing the capacity of ecosystems to support human consumption of food and environmental goods and services is the need of the time.

Context

More than two third of Bangladesh may be classified as wetland according to the definition enunciated in the Ramsar Convention[24]. About 6.7 percent of Bangladesh is always under water, 21 percent is deeply flooded (above 90 cm) and 35 percent experiences shallow inundation (FAO, 1988). The wetlands in Bangladesh are very rich in terms of their biological diversity and a wide variety of dynamic ecosystems. The vast floodplains are predominantly used for growing rice paddy which is adaptable with flood and inundation. Before the introduction of mechanized dry-season irrigation in the 1960s, deepwater rice (locally known as broadcast *aman* rice) used to be the major crop in the wetlands during the monsoon (June-September). This crop was sometimes mixed with short duration *aus* rice to be harvested in June, allowing broadcast *aman* to grow till October. Along with the introduction of irrigation and HYV there has been a change in cropping pattern in which HYV boro rice got preference over broadcast aman and aus. At one time (18th century), undivided Bengal had about 15,000 varieties of cultivated rice but the germplasm of most of them is now lost, leaving only about 6,000 varieties. However, the recent trend of high rainfall variability is leading to early heavy rains responsible for considerable damage to

[24] The RAMSAR Convention has defined wetlands as "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters". Thus the term wetlands groups together a wide range of inland, coastal and marine habitats which share a number of common features (Dugan 1990; cited in Aninun Nishat, 1993)

these crops. During winter, the depressions known as *haor* wetland basin are planted with HYV boro paddy. In recent decades, almost all seasonal wetlands are now used for cultivation of HYV rice in the dry season. Landholders are engaged in crops cultivation in different season of the year. Landless and poor people are employed in crop fields as wage labourer or as sharecropper.

Wetland Ecosystem Degradation- Declining Rice Paddy Growing Area

Degradation of wetlands in Bangladesh has mainly happened due to population pressure on scarce land and expansion, as well as intensification of agriculture and subsequent conversion of wetlands through drainage into rice fields (including flood control and irrigation project development for enhancement of agricultural productivity). This problem was further aggravated by constructing national, local and rural infrastructures which did not include adequate Environmental Impact Assessments (EIA). Other relevant issues include over-grazing by livestock; over-fishing and associated disturbances; siltation due to degradation of watershed areas which are often trans-boundary in nature; indiscriminate control/ regulation / use of water flows of main river systems in upper riparian; and pollution of water due to industrial, urban, agrichemical and other types of pollutants including pollution from trans-boundary sources. It is estimated that each year 1 percent of the agricultural land is converted for other purpose which is an alarming signal from the food security perspective.

A number of studies were carried out to understand the impact of water management projects on agriculture e.g., Flood Control/Drainage (FCD/ FCDI) projects, Flood Action Plans (FAPs) and Compartmentalization Pilot Projects (CPP) where fisheries impacts have been identified. Every study has also pointed out that the rice paddy production fon the floodplains along with their fisheries are declining. Due to the construction of embankments, sluice gates, culverts and other structures, monsoon floodwater can not enter into the floodplains quickly and there is less floodwater. Fish fry could not enter into the floodplains, because of the delay in floodwater flow into the area.

Degradation of the wetlands in Bangladesh has created the following impacts:

- Serious reduction of wetland, rice and fish habitat, fish population and diversity;
- Extinction and reduction of micro-organisms, wildlife including birds and reptiles;
- Extinction of many indigenous varieties of rice with the propagation of high yielding varieties;
- Loss of many indigenous aquatic plants, weeds and shrubs;
- Loss of natural soil nutrients;

- Deterioration of living conditions;
- Loss of natural water reservoirs and their resultant benefits; and
- Degeneration of wetland-based ecosystems, occupations, socio-economic institutions and cultures.

Conservation Challenge of Coastal Wetland

The coastal wetlands of Bangladesh have experienced a silent disaster since 1960's when engineering solution implemented the coastal embankment aimed at protecting the area from tidal in-flow for agricultural production had changed the biophysical system. These wetlands were complex and biologically high productive ecosystem. Development practitioners and policy makers in those days considered wetland as the waste land and could not understand the ecological significance of wetland and planned to convert the brackish water ecosystem to terrestrial ecosystem. Those protected area encircled by embankment lost process of continuous land formation under active deltaic system. Since land development process seized inside the protected area, it became a pond over time as rainwater as well as seepage in monsoon failed to drain out. More over this coastal area is again subject to land subsidence which was naturally used to balance by siltation, now under changed scenario water logged situation further aggravated. The adverse environmental impacts are observed through enhancement of siltation of river, leading to drainage congestion, water logging and salinization. In 1970 and onwards international demand for shrimp were gradually rising. Consequently, people switched over rice-paddy to shrimps in their culture ponds for increased profitability. After few years, the paddy fields had been converted dramatically in to shrimp cultivation.

Pollution Status of the Wetlands

The pollution problems mostly originate from 'abuse, misuse or cocktail' use of pesticides, and overdose and untimely application of fertilizers and from domestic wastes. All the rivers flowing through Bangladesh originate outside the country and these carry heavy loads of silt, sediments and other debris, including domestic, agrochemical and industrial wastes, from far-away places. Together with these, local wastes are added, thus making the water saturated and at times oversaturated with organic and inorganic pollutants. The wetlands of the whole country are the dumping grounds for these sediments and pollutants and flushing out of materials to the sea is quite slow. The result is serious deterioration of the aquatic resources which has direct and indirect impact on food chain with increased trend of toxic elements including rice paddy. Particularly ground water contamination with Arsenic used for supplemental irrigation in rice paddy field in dry season is another potential threat to ensure safe food and nutrition.

Most of the industries and factories are situated on the banks of the rivers or very close to a river system and the effluents and wastes are mostly thrown directly in the river water without any treatment to make the effluent ‘safe’ from the biological standpoint. As a result, the depletion of the biotic components near the sources is observed. A preliminary survey near the tanneries in Dhaka on the river Buriganga will reveal this fact. As the rivers are connected with each other and different mills and factories are situated on their banks, the recovery time of the water from the effects of the effluent is very low, and during the non-monsoon period, conditions become worse.

Whatever industries we already have are enough to render the entire wetlands of Bangladesh including the river systems ‘biologically dead’ if the conditions now prevailing are allowed to continue further. Many of our industries are creating hazardous conditions in their locality with continual disposal of toxic and harmful materials.

The industrial effluent containing acids, heavy metals, ammonia, toxic substances, etc., are directly thrown untreated into the water, and together with these, are added the agrochemical substances (insecticides, pesticides, fertilizers etc.) and the huge quantity of domestic wastes making the situation worse (influenced by the pressure of the human population for food, shelter, fuel and clothing). Th esanitation problem alone has created an enormous health disaster in addition to the damage of the biological environment and its useful organisms.

Resources use pattern have been changing

Traditionally the wetland areas of the northeast were very sparsely populated. The rapid growth of population in the century has accelerated the process of settlement in these hitherto marginal and agriculturally unproductive lands. A significant area of wetland was covered by various types of forest including some unique and almost extinct freshwater mangrove species. Cultivable waste and fallow lands surrounded the wetland area villages, as population pressure on land was not as severe as it is now. Occupational pattern and resource harvesting in wetland areas are also one of gradual change and transformation. At the early stage of settlement, fishing and cultivation of deepwater broad cast *aman* paddy were the main activities of the wetland people. Gradually over time, this transformation into extraction of other aquatic resources and looking for other livelihoods earning opportunities, as competition for available resources stiffened. Land use pattern in the wetland such as *haor* basin depends on the land elevation. Since the basin is saucer shaped, its peripheral highland is used for homestead and adjacent to the homestead a patch of land and the sloping terraces are kept for vegetable gardening and post-harvest activity. The next hierarchy of land starts for agricultural use which is relatively higher in elevation, followed by the medium and low land. The lowest depression is the *beel* or permanent water bodies. Beels are the habitat for the fish of the *haor* and the source of supplemental irrigation during dry season for rice paddy.

Indigenous Knowledge of Farmers

Over the years, the farmers in many floodplains have found various ways of improving their farming techniques and adapting to their situation. Wetland remains submerged in water during a considerable time of the year. This restricts farming activities severely, but the farmers of different floodplains have adopted the practice of making floating gardens using water hyacinth for growing seedlings. They also cultivated nodular plants to increase the soil fertility and for a protection against wave erosion. The sections below give details of these two indigenous techniques used by the farmers in Chanda Beel area.

Floating Agriculture locally known *Baira* / Hydroponics

UNDP and CARE Bangladesh has supported promotion of several community initiatives on floating agriculture through Sustainable Environment Management Programme (SEMP, UNDP) and Reducing Vulnerability of Climate Change (RVCC, CARE) in southern Bangladesh. Bangladesh is experiencing the adverse impact of coastal embankment and further aggravated by the emerging climate change and variability such as frequent prevalence of extreme cyclone and tidal surge events, rise in tidal wave, water logging, poor drainage, sedimentation and saline water intrusion. Th estudy reveals the fact that new areas are coming under the flood zone over time. Subsequently, disruptions happened in farming practices as the natural habitat is changing faster than farmers can cope up with the situation. Floating agriculture is an indigenous farming technology needs to be disseminated and up scaled as an opportunity to adapt with the water risk and adverse affects of climate change as a new farming option.

Flood Plain Resource Management

Community Based Haor and Floodplain Resource Management (CNHFRM) components of the Sustainable Environment Management Programme supported by UNDP had implemented ecosystem based wetland habitat restoration and conservation engaging community in a way which provides ecosystem services to the community as well. Pilot initiatives were appreciated for achieving the target goal to achieve sustainable wetland management by addressing location specific issues such as environmental problem, livelihood challenges, conservation barriers and management options. These participatory initiatives started with resource inventory, problem identification and solution recommendations accordingly, prioritization, planning needed interventions, and follow-up implementation.

Concluding Remark

Since the green revolution, the main concern of food security related development programmes and research has been to maximize high levels of food production together with low prices to consumers. Mainstream agricultural science has ignored negative impacts or externalities including displacement of indigenous variety of crops and environmental as well as wetland pollution. A long-term strategic research and sustainable management agenda for the public sector needs to be defined that is new and relevant to present efforts to integrate eco-friendly natural resource management and sustainable agricultural production. Such an agenda must be understood as a way of managing natural resources in general and floodplain ecosystem management in particular for the production of food and environmental services essential to human well-being. If agricultural systems are viewed and managed as parts of whole ecosystems, the key properties of complex systems that need to be taken into account will force researchers to consider long-term effects and environmental externalities. This paper first elaborates on this argument of the integrated natural resource management approach considering environment and climate change aspects, with examples of approaches that show rice paddy being the most adaptable crop. It can play an important role to ensure the conservation of wetlands, as well as giving special attention to mainstreaming wetlands into agricultural science and the development programme to help meet the emerging climate change impact.

The *Satoyama* Initiative
- Advancing Socio-Ecological Production Landscapes for the Benefit of Biodiversity and Human Well-being -

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The Ministry of the Environment of Japan (MOEJ) and the United Nations University Institute of Advanced Studies (UNU-IAS) are working together towards the launching of the International Partnership for the *Satoyama* Initiative (IPSI) at the tenth meeting of the Conference of the Parties (COP 10) to the Convention on Biological Diversity (CBD).

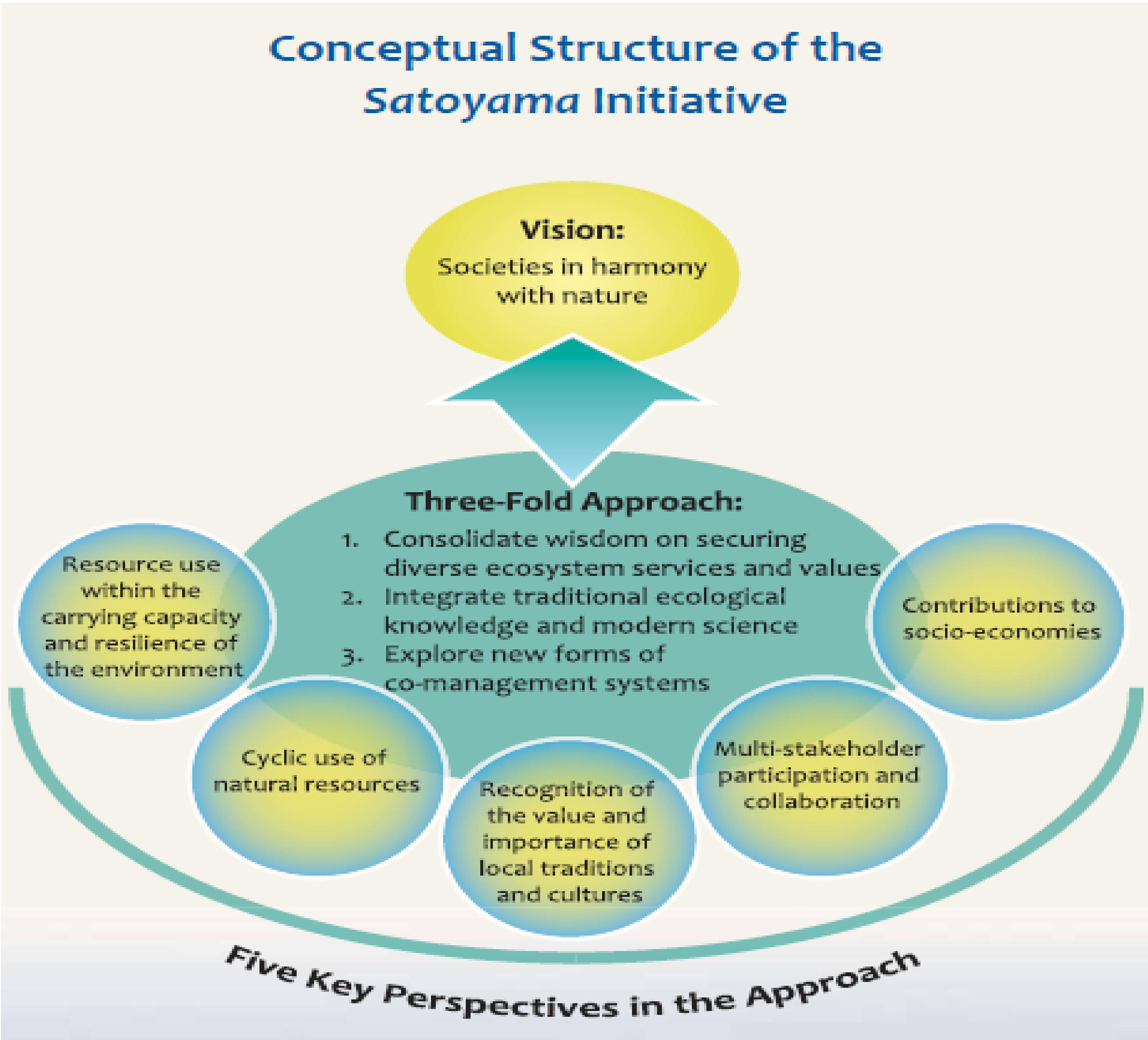
The *Satoyama* Initiative (SI) is an initiative for the promotion and support of socio-ecological production landscapes (SEPLs) and thus maintaining and/or enhancing their contribution to human well-being and the three objectives of the CBD. SEPLs are dynamic mosaics of habitats and land uses shaped through long-term interactions between people and nature (cultural heritage), including sea-scapes, and compatible with the Ecosystem Approach and Guidelines on Sustainable Use, where natural resources are used, re-used, recycled in a cyclical manner within the carrying capacity and resilience of ecosystems.
Through the collection of cases around the globe, UNU-IAS found SEPLs in many regions of the world under various local names, for example; *Muyong*, *uma* and *payoh* in the Philippines, *Mauel* in Korea, *Dehesa* in Spain, *Terroirs* in France and other Mediterranean countries, *Chitemene* in northern Malawi and Zambia, and *Satoyama* in Japan. There are commonly wise and sustainable use of biological resources in accordance with traditional and, in some cases, modern cultural practices.

SEPLs are beneficial for both people and biodiversity: they provide humans with goods and services needed for their well-being (provisioning, regulating, cultural and supporting services) as well as maintain biodiversity; achieve optimal balance of food production, livelihood improvement and ecosystem conservation, thus contribute to the achievement of MDGs and national development policies; they provide sense of roots and identity; contribute to the mitigation of and adaptation to climate change; play a role in achieving connectivity/corridor conservation; thus they can provide useful tools for implementing CBD and post 2010 Strategic Plan.
However, they are threatened in many parts of the world: some are abandoned because of rural depopulation in search of employment and better living conditions and ageing populations; some are lost because of unplanned urbanization, industrialization encroaching

on SEPLs; and some are overexploited or degraded due to increase in population/resource demand. As a consequence, ecosystem services are declined, which has serious impacts on the local and broader communities and biodiversity.

Therefore, urgent measures are needed for SEPLs to support and maintain existing ones and to revitalize or rebuild degraded or abandoned ones. That is the reason why MOEJ and UNU-IAS propose the *Satoyama* Initiative.

The vision of the Initiative is "Realizing Societies in Harmony with Nature", building positive human-nature relationships by maintaining and developing socio-economic activities (including agriculture, forestry and fishing) in alignment with natural processes and ensuring that biological resources are managed and utilized in sustainable manner, so that biodiversity can be maintained and humans can enjoy a stable supply of various benefits of nature (ecosystem services) well into the future. To achieve the vision (long term goal) of SI, we propose to carry out activities in accordance with the following three-fold approach, which in concrete terms entails the following five perspectives:



The Initiative intends to achieve; i) better understanding and awareness raising of the importance of socio-ecological production landscapes for livelihoods and the three objectives of the CBD, ii) providing support to existing socio-ecological production landscapes and enhancing capacities, through such as regional workshops, for on-the-ground projects to maintain, rebuild and revitalize socio-ecological production landscapes, and iii) collaborating with other initiatives dealing with socio-ecological production landscapes (e.g. GIAHS (Globally Important Agricultural Heritage Systems) of FAO, ICRAF (World Agroforestry Center), IUCN, Bioversity International, Planete Terroirs, UNESCO, UNEP, UNDP etc.) and/or strengthening synergies with partners, including local community organizations, national/local governments, donor agencies, IOs, NGOs, and other UN agencies and organizations.

With regard to i) above, UNU-IAS would like to collect as many case studies as possible from partners and conduct collaborative projects with partners, analyse these case studies and collaborative projects and distil good practices and lessons learned and put them on searchable online database, develop measurable indicators of resilience for SEPLs. UNU-IAS would also like to conduct research on ways and means to consolidate wisdom on securing diverse ecosystem services and values, integrate traditional ecological knowledge and modern science to promote innovations, explore new forms of co-management systems or evolve frameworks of "commons", revitalize and innovate SEPLs and integrate policy results and decision-making and use all these materials for dissemination and education promotion.

Enabling mechanisms to support the *Satoyama* Initiative would be; i) an International Partnership to carry out, as much as possible in synergy, the activities identified by the *Satoyama* Initiative and individual activities, which is linked to national/sub-national and regional partnerships and open to all organizations dealing with socio-ecological production landscapes, ii) financial mechanisms for the implementation of the Initiative and related projects and activities of the International Partnership, and iii) reporting to CBD SBSTTA (Subsidiary Body on Scientific, Technical and Technological Advice) and COP in accordance with CBD Programme of Work, and with milestones for MDGs (Millennium Development Goals) 2015.

The International Partnership will ensure synergy and complementarities among all the activities of participating organizations and maximize resources and strengthen the work of each other with knowledge, expertise, etc., and it is expected that national or local governmental organizations, non-governmental or civil society organizations, indigenous or local community organizations, academic, educational and/or research institutes, industry or private sector organizations, United Nations or other international organizations, and others will join the international partnership.

With regard to the financial mechanisms, we can use existing ones, such as Japan International Cooperation Agency (JICA) and Critical Ecosystem Partnership Fund (CEPF). JICA is carrying out several technical cooperation projects at SEPLs in developing countries and will start training course on *Satoyama* from 2010. CEPF is a joint program of Government of Japan, Agence Française de Développement (AFD), Conservation International, Global Environment Facility (GEF), MacArthur Foundation and World Bank, and targets biodiversity hotspots in developing countries, goes directly to civil society groups, contributes to economic well-being and social stability, and achieves results that are tangible, replicable and scalable.

In addition to these existing financial mechanisms, the Government of Japan is now discussing with CBD Secretariat and UNDP to use GEF Small Grant Programme to support on-the-ground SEPL projects in developing countries. Close coordination will also be necessary with other potential donors and development agencies.

The Ministry of the Environment of Japan and the United Nations University Institute of Advanced Studies have organised several preparatory workshops and meetings from 2009 to discuss vision, objectives and possible activities of the *Satoyama* Initiative. One of the primary outcomes of the Global Workshop held in Paris in January 2010 was the Paris Declaration, which contains adscription of the *Satoyama* Initiative, its objectives, headline activities and mechanisms for its operationalisation and is the basic document of the Initiative. At the preparatory meeting held in August 2010 in Yamanashi, Japan, participants discussed operational framework of the International Partnership for the *Satoyama* Initiative (IPSI) and possible joint activities under IPSI.

MOEJ and UNU-IAS will launch the International Partnership at CBD COP 10 and expect many partners can join the IPSI, and also expect the decision on the Initiative be successfully adopted at COP 10 in October 2010 in Nagoya, Aichi, Japan. All the necessary information can be found at the portal site (http://satoyama-initiative.org/).

Rice Cultivation and Wetlands in China

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Introduction

Rice is a common wetland flora and one of the many resources produced by wetlands. It has played a significant role in the evolution of agriculture throughout the history of civilization. Rice growing can be dated back to the costal wetlands of eastern China some 7,700 years ago. Rice is not only the crop with the longest history but it also feeds the greatest number of people. It is estimated that rice now feeds over half the world's population.

Cultivated rice originated from the common wild rice species. Common wild rice grows in swamps and marshes and can be found in the Guangdong, Guangxi, Yunnan, Jiangxi, Hunan and Fujian Provinces of China. The biological character of cultivated rice and common wild rice is so close that it is considered that wild rice is the only ancestor of the cultivated rice varieties that have now spread so widely throughout the world.

Over its long history, cultivated rice in China has increased in variety with more than 40,000 local strains now grown. Cultivated rice is not only a man-made wetland crop, rice production also depends on the wild rice that grows within natural wetlands. The natural wetlands have both biological and economic benefits that are supported by the successful genes of wild rice. Such genes have developed through the processes of natural succession and evolution.

The development of hybrid rice

Professor Yuan Longping, a chinese agricultural scientist, is a pioneer in hybrid rice research and has achieved remarkable results by developing the first hybrid rice in the world. Yuan began researching hybrid rice in 1964 and developed a "three-line system" of hybrid rice (male sterile, maintainer and restorer), and obtained the world's first high-yielding hybrid rice strains in 1973. Yuan made breakthroughs in hybrid rice breeding and perfected production techniques by 1984. He has been praised as the "father of hybrid rice" for his contribution to hybrid rice development in China, which is now the world's most advanced.

The achievements of Yuan Longping have greatly contributed towards the problems of worldwide food shortages and starvation. The creation of hybrid rice is regarded as China's fifth greatest invention and is acclaimed as the Second Green Revolution. Yuan’s pioneering work in hybrid rice breeding and production techniques revolutionized rice cultivation in China and established China as the world leader in hybrid rice research. In 1979, the hybrid rice was transferred as China's first agro-technology patent to the United States. Today, the hybrid rice developed by Yuan is planted on farmlands all over China and it continues to play an important role in increasing China's grain production. It is estimated that China feeds 22% of the world’s population on only 7% of the world's total arable land. This shows the importance of swamp wetlands to rice production, as the hybrid rice achievement would not have been possible without the wild rice growing in wetlands.

The importance of China’s rice fields

In 2009, more than one billion people — one sixth of the world's population — suffered from hunger. Rice is grown in 120 countries worldwide and, as the staple diet for over half the world’s population, it has contributed to about 20% of the total calorie supply in the world. The global average yield of rice is however only 200 kg per mu. Global food supplies must increase by an estimated 50 percent to meet expected demand in the next 20 years. The creation and application of high yielding hybrid rice creates ideal conditions for self food supply in many countries.

There are more rice crops in China than any other food crop. China is the largest rice production and consumption country in the world and rice is the staple diet for over 60% of the population. The rice fields in China account for 20% of the world’s total rice growing area and 30% of the world’s total rice yields – more than any other country. Despite the high yields, there are still challenges concerning an increase in population and a reduction to cultivated areas in favour of development. China’s population is projected to reach 1.6 billion by 2030, and the yield of rice must increase 50% to meet food demand. Economic development, population increase, water shortage, cultivated area reduction, soil erosion, desertification and pollution all seriously obstruct the development of rice cultivation in China. Global warming and planting structure adjustment have also impacted rice cultivation by accelerating plant diseases and the breeding of pests.

Rice fields are the largest kind of human-made wetlands and are as important as natural wetlands for the ecosystem services they provide. Not only do they produce food, but they also play an important role in maintaining ecological balance. Expansive rice fields are also huge water reservoirs that can help to control flooding. For example, there are 2,500,000 ha of rice fields in the Yangtze River estuary region with a water storage capacity of two and a half times that of Taihu Lake. Therefore, these rice fields are the largest water storage and flood control reservoir in this area.

Rice fields also have an important water purification function. When water is irrigated into a rice field, sand and impurities are deposited and chemicals such as nitrogen and phosphorus are absorbed. Rice fields also provide many other ecosystem services such as groundwater recharge, soil erosion control, air purification, local climate regulation, amenity and social benefits. The soil within rice fields also absorbs greenhouse gases – a valuable function that can help mitigate the challenges faced by climate change.

Rice fields in China support important wetland biodiversity, with a variety of species such as reptiles, amphibians, fish, crustaceans, insects and molluscs all finding habitat within the fields. Rice fields also play a significant role in waterbird flyways and the conservation of waterbird populations. Thousands of waterbirds use rice fields in Liaoning Province as a staging site during their southward migration.

The rice-growing cultural heritage in China has been recognized for its international importance. The famous hani terrace field in Yunnan Province is categorized as a 'constructed wetland' under the Ramsar Convention classification and recently, the hani terraced fields of Honghe River were identified by the Food and Agriculture Organization of the United Nations as a pilot site for the Globally Important Agricultural Heritage Systems, or GIAHS. Over the past 1,300 years, the Hani terraced fields downstream of Honghe River were gradually formed with a unique ecological system of forests, villages, terraces, and water streams. The aim of the GIAHS project is to retain the unique ecosystem and build upon the local agricultural knowledge.

Opportunities for China's rice fields

The inappropriate use of pesticides and chemical fertilizers in rice fields causes pollution and rice growing models using such techniques should consider reform. More "green rice fields" with uniform planning and strict management control should be developed and promoted. Under a "green rice field" model, the environmental impacts are managed with natural fertilizer and pest prevention being encouraged and any synthetic fertilizer or pesticide use is strictly controlled.

The new agricultural model of "rice field + aquaculture" should also be encouraged and promoted. This model which closely links rice planting and fish farming increases productivity of the land and water resources. The "rice fields + aquaculture" model is referred to as "1+1=5", that is, the model of combining two agricultural practices gives five benefits including grain security, food security, ecological security, increased income and increased efficiency.

Another opportunity for rice in China involves the use of wetland parks. Patches of rice could be grown within selected areas of wetland parks. Rice is a water plant similar to reeds or cattails which are commonly found in wetland parks. Planting rice crops in parks has the potential to provide not only food but a good popular science and agriculture educational site for urban children. Both Jinghu National Urban Wetland Park and Cixi National Wetland Park have rice fields which are managed for both tourism and research.

Comparisons of bird communities of organically and conventionally grown rice field in Korea

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This study was conducted to clarify the differences in bird communities in eight-years organic, one-year organic and conventional rice field between May 2008 and June 2009 in Wanju County, Jeonnam Province, Korea. 178 individuals out of 16 bird species were observed and bird species abundance and diversity were least in one-year organic rice field. This result might be related to the amounts of invertebrate as food resources.

1. Introduction

Many species inhabit the earth and maintain close relationship with other species. 1970s' rapid economic development has led to affect nature and other wildlife, causing habitat loss in Korea.

Rice fields are a form of wet land which has important function as habitat to invertebrate, amphibians, reptiles and birds (Chamberlain et al. 1999). According to farming methods, population of invertebrate, amphibian, reptile and birds can be changed. Also, it can affect to bird species abundance and communities. Many studies on relationship between wildlife and farming methods have researched already in other county. Studies in Europe have shown that bird species diversity and communities were significantly different by management of farmland (Fuller et al. 1995). Species diversity and richness were higher in organic farm compare to conventional farm. Population of invertebrates are increased in organic farm (Chamberlain et al. 1999).

Rice is the staple food for many Asia-countries. Several studies have reported about function and impact as habitat of rice field from Japan. Unlike Japan, Korea has little understanding about rice field as important habitat to wildlife. Objective of this study was to clarify the use of rice paddy on bird species and understand differences in bird abundance and diversity in the organically and conventionally grown rice field.

2. Methods

2.1 Study area

Our study area was located at the Gosan-myun, Wanju County, Jeonnam Province, Korea(Fig.1). We selected three types of rice field (Fig.2, A:Sungjae-ri-conventionally grown, B:Yulgok-ri-organically grown 1year, C:Hwajoeng-ri-organically grown 8years).

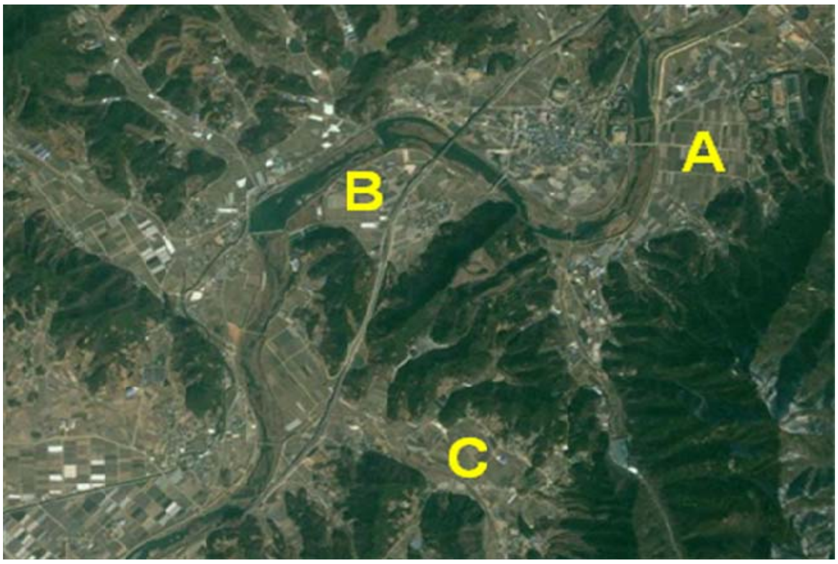

Fig. 1 Study areas

Fig. 2 A:Sungjae-ri, B:Yulgok-ri, C:Hwajoeng-ri

2.2 Study methods

Field surveys were conducted 7 census visits in each study areas from May 2008 to May 2009 (May, June, July and September in 2008, April, May and July in 2009). We recorded every bird species from sunrise when birds are the most active from the place where we can observe study area at a glance. To collect the data, we identified bird species with shape, song and behavior.

2.3 Statistical methodology

Species abundance indices were calculated per site using the Shannon-Weaver index(1949). Formula is as follows. P_i is the proportion the *i*th species contributes to the total number of individuals of all species.

$$H' = \sum_{i=1}^{s} (-P_i) \times \ln(P_i)$$

We used nonparametric multiple test (Kruskal-Wallis test) to compare bird species, population, species abundance by study areas.

3. Results and discussion

3.1 Bird species abundance

We observed 191 individuals out of 16 species (Table 1, Fig2-7)). Cattle Egret (*bubulcus ibis*) was the most dominant species in the study area. 47 individuals out of 9 waterbird species and 90 individuals out of 7 mountain bird species were observed.

Fig2. Cattle Egret (*bubulcus ibis*) Fig3. Mandarin Duck (*anas poecilorhyncha*)

Fig4. Grey Heron (*ardea cinerea*) Fig5. Dusky Thrush (*turdus naumanni*)

Fig6. Grey Starling (*sturnus cineraceus*) Fig7. Tree Sparrow (*passer montanus*)

Table1. Bird species in the 8 years organic, 1 year organic and conventional farm

English name	**Scientific name**	**organic (8 yrs.)**	**organic (1 yr.)**	**conventional**	**Total**
Grey Starling	*sturnus cineraceus*	25	0	2	27
Rufous Turtle	*streptopelia orientalis*	21	3	2	26
Black-billed Magpie	*pica pica*	11	5	1	17
Barn swallow	*hirundo rustica*	4	0	0	4
Ring-necked Pheasant	*phasianus colchicus*	5	0	0	5
Great Egret	*egretta alba*	11	4	0	15
Intermediate Egret	*egretta intermedia*	3	0	0	3
Little Egret	*egretta garzetta*	9	2	0	11
Grey Heron	*ardea cinerea*	1	0	0	1
Cattle Egret	*bubulcus ibis*	31	1	5	37
Spot-billed Duck	*anas poecilorhyncha*	8	4	5	17
Mandarin Duck	*anas poecilorhyncha*	4	0	2	6
Tree Sparrow	*passer montanus*	13	2	0	15
Olive-backed Pipit	*anthus hodgsoni*	4	0	0	4
Little Ringed Plover	*charadrius dubius*	0	2	0	2
Dusky Thrush	*turdus naumanni*	0	1	0	1
No. of individuals		**150**	**24**	**17**	**191**
No. of species		**14**	**9**	**6**	**16**
Species diversity index (H')		**2.33**	**2.07**	**1.64**	

Bird species abundance was significantly different among study sites (Kruskal-Walis test, Table 2). 150 individuals out of 14 species in 8 years organic farm, 24 individuals out of 9 species in 1 year organic farm and 17 individuals out of 6 species in conventional farm were observed. In organically 8 years grown was the highest. This result might be related to the amounts of invertebrate as food resources. There were no differences in species diversity index among study sites.

Table2. Differences in the mean numbers of species, individuals and sepcies diversity in the 8 years organic, one-year organic and conventional farm (Kruskal-Wallis test)

	organic (8 yrs.)	**organic (1 yr.)**	**conventional**	**H**	**P-value**
No. of species	[1]5.14±1.95	2.43±1.81	1.57±0.98		0.022
No. of individuals	21.17±12.28	3.43±2.76	2.43±1.72		0.010
Species diversity	0.25±0.10	0.24±0.09	0.24±0.12		0.765

3.2 Seasonal changes in bird communities

Bird communities were changed by season (Fig8, 9). Number of mountain birds was higher than waterbirds before supplying water in the rice field (April and May) to forage invertebrates in dried rice field. In contrast, Number of waterbirds was higher than mountain birds' while a number of aquatic invertebrates and amphibians' were increasing after supplying water in the rice field (June and July). Densities of waterbirds decreased in September due to difficulty of foraging when rice was grown.

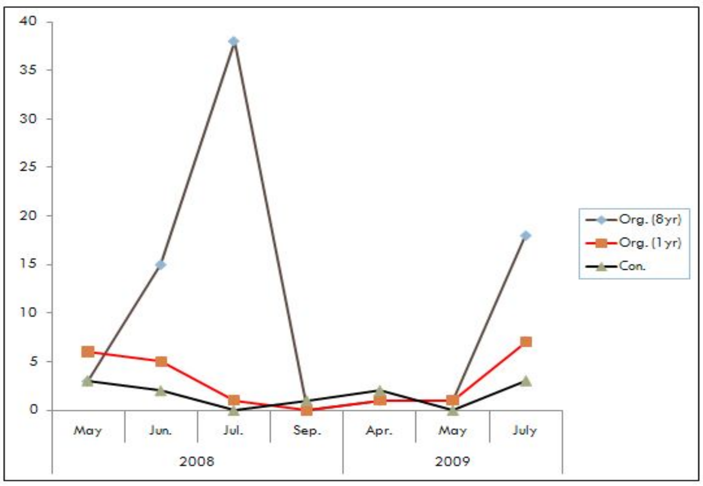

Fig8. Seasonal differences in number of waterbirds species

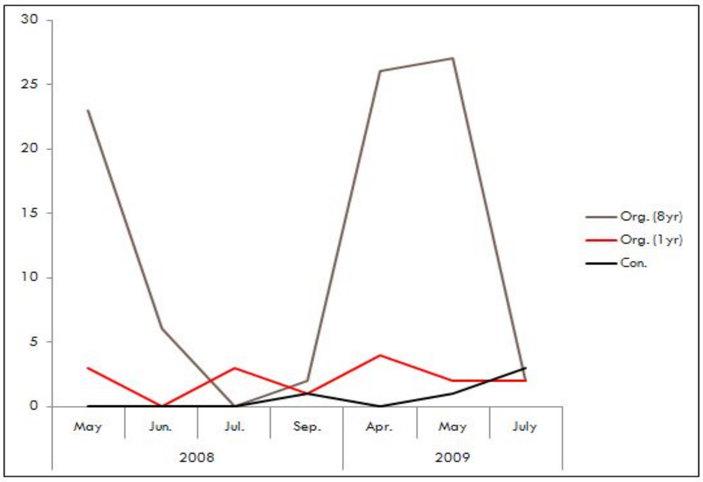

Fig9. Seasonal differences in number mountain birds(right) species

4. Conclusion

Rice field is one of important habitats for many bird species and organic farming could be positive effects for bird species. Bird species abundance was significantly higher on organic rice field. Also organic farm had consistently higher densities of both individual species and of all species than conventional rice field. Although bird species abundance of organic rice field was higher than conventional rice field, there was no distinct difference between 1 year organic rice field and conventional rice field. This was caused by chemicals which remain in soil was affected to aquatic invertebrates' breeding. Therefore, long-term monitoring should be conducted to understand the changes in bird abundance and communities by elapsed time.

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Integrated Rice Paddy Farming in Thailand : A Best Practice for Maintaining Ecosystem Services

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ABSTRACT

Rice paddy farming has been practiced in Thailand for many thousands of years. This paper describes how rice paddy fields and rice farming are important and reviews the trend of rice farming practices in Thailand. The paper then discusses how integrated rice paddy farming plays an important role in maintaining ecosystem services with special emphasis on biodiversity conservation, provision of food and medicinal plants, and enhancement of food and health security.

Keywords : *Integrated rice farming, ecosystem services, food and health security, Thailand*

Introduction

Thai people and their ways of life have been associated with rice fields for more than 5,500 years. Rice farming has been a principal career of the Thais and rice farmers are named '*the backbone of the country*'. An old saying '*In the water, there is fish. In the fields, there is rice.*' clearly indicates the fertility and importance of rice fields as '*Rice and Water Bowl*' of Thailand. Majority of people, especially in the rural areas, depend on rice fields for their subsistent livelihood, sufficiency economy, food and health security.

The author has carried out a preliminary documentary research, compilation and synthesis of data and information related to rice paddy fields and farming practices from a number of different sources. The objectives of this paper are to emphasize the importance of rice paddy fields and rice farming, to review the trend of rice farming practices in Thailand, and to discuss how integrated rice paddy farming can play an important role in maintaining ecosystem services. This paper puts special emphasis on biodiversity conservation issues and how integrated rice paddy farming practices can provide food and medicinal plants and enhance food and health security of the rice farmers as well as of the public at large.

Importance of rice fields and rice farming

Rice fields are multi-resource agro-ecosystems within an agricultural landscape, having significantly high cultural and spiritual, socioeconomic, and ecological values.

Culturally and spiritually, rice fields are intimately linked with the Thai ways of life and settlements, history and archaeology, beliefs and rituals, religion, culture, literatures, legends, festivals and ceremonies, folklores and folk arts. Rice field ecosystems are perfect natural classrooms, laboratories, research and training sites, where children and youth, students and general public can gain life-long environmental education.

Socio-economically, for agriculture-based developing countries, rice paddy fields and rice farming activities are vitally important for sustainable development. Rice fields are sources of rice which is the staple food, sources of fish and many other aquatic animals which are major protein food, various edible food plants, a wide range of valuable herbal and medicinal plants, and many natural products which can be collected and used for firewood, fodder, compost and green manure, housing materials, household utensils, many domestic tools, raw materials for cottage industries, and many others. Rice fields are not only important for subsistence and sufficiency economy of local people, but also for the national economic development. Rice fields are sources of occupation and income of majority of rural households, while producing rice which is the prime export and a major source of the country's revenue.

Ecologically, rice fields provide multiple ecosystem services. Ecosystem services provided by rice fields are such as provision of food resources, provision of medicinal plants, conservation of biodiversity, groundwater recharge, flood control, sediment trapping, water purification, nutrients retention, soil fertility replenishment, erosion control, landslide prevention, microclimate stabilization, and many others. Rice paddy landscapes are among the most diverse ecosystems and are important for biodiversity conservation. In rice fields, there is a high diversity of plants, fish and aquatic animals, birds, small mammals, amphibians, reptiles, insects, and invertebrates. Such biodiversity-rich habitats are important to local farmers and their livelihoods because they are home to the natural enemies in the fields. Each and every species plays important role as predator or prey in natural food webs and food chains and keeps rice field ecosystems in balance.

Rice paddy farming practices in Thailand : past, present and future

In the past, almost 90% of Thailand's rice fields were naturally flooded for 3 – 4 months every year, with average depth of 1 – 2 m to 6 – 7 m during October to January. Rice farmers considered this condition as a naturally annual event supplying nutrients and fertility to their rice fields. During the mid 20th Century, massive irrigation systems and networks have been developed and water level has been controlled. A huge area of intensive rice plantation has occurred. Since 1960, Thailand has been one of the biggest rice exporters in the world. During 1960 – 2000, hydrological changes have brought along various changes in Thailand's rice fields and rice farming practices and patterns : from natural to controlled flooding; from rainfed broadcasting native deepwater floating rice cultivation to irrigated high yield varieties transplanting rice cultivation; from 1 crop/year to 2 – 3 crops/year; from natural organic to chemical rice farming; and from using intensive household labour and animals to using mechanized heavy machineries. Average rice yield has increased double to triple times from 280 to 530 – 850 kg/rai/year *(1 rai = 1,600 sqm)*. In 2007, Thailand has approximately 21% of the total country area under rice fields, and has 10% of the total country area under irrigation which is about 30% of the total agricultural area.

At present, rice farmers as well as the general public have started to be aware of impacts and consequences of changes occurred during the past 5 decades, and increasingly realized the importance of rice field biodiversity conservation. Intensification of rice cultivation, over-application of chemical fertilizers and pesticides, and modern mechanization changed the composition of plant species assemblages and threatened the availability of wild food and medicinal plants as well as ecological balance in rice fields. Trend of changing back to organic and integrated rice farming practices have occurred and been widely accepted.

Integrated Rice Paddy Farming in Thailand : A Best Practice for Maintaining Ecosystem Services

In Thailand, organic rice farming started in 1980s. Currently, organic rice farming areas and networks continuously expand and exist country-wide. Organic rice farming has been promoted and encouraged, providing the rice yield of 400 – 650 kg/rai/year. Price of organic rice is 5 – 20% higher than of chemical rice. Many people are willing to pay 30 – 40% more for organic rice. Adoption of organic rice farming with much less or zero application of agricultural chemicals and zero-waste farming system has also made integrated rice farming practices possible. In place of rice monoculture, integrated rice farming practices maintain the natural species composition and mimic the natural ecosystems by combining many diverse but compatible farming and cropping activities within rice fields and avoiding applications of chemical inputs. Integrated rice farming practices are such as rice-fish culture, rice-fish-duck culture, rice-bean-poultry-livestock culture, rice-fish-orchard-vegetable culture, rice-fish-agroforestry, and many others. These integrated farming systems following His Majesty the King's Philosophy of Subsistence Economy and the New Theory, have been widely practiced and increasingly popular. The outcomes not only bring a better environment and quality of life, lower expense and sufficient benefit, but also reduce the risk from climate variability, cropping failure and problems of low farm-product prices. Research results clearly indicated that rice-fish plots had higher available phosphorus and organic matter contents than rice plots without fish (Khunnarong, 1996). The economic analysis also indicated that in rice-fish culture, the chemical fertilizer application could be reduced by 25%, while the profit was still higher than rice culture without fish (Kaewvichit, 1996).

In terms of ecosystem services, integrated rice paddy farming helps bring back the healthy ecosystems and their valuable functions. By maintaining the natural biodiversity of rice paddy fields and less or zero application of agricultural chemicals, the importance and functional values of rice paddy fields can be significantly enhanced.

Within paddy fields (wet rice fields), there are 3 major types of different habitats : rice paddy fields, bunds, and ditches. These habitats are home, feeding, nesting, roosting, and breeding grounds for diverse groups of wetland species. Not only rice plant which is the dominant species, but also within rice paddy ecosystems there are at least 54 recorded aquatic plant species; large number of grasses, sedges, broad-leaved plant species; at least 69 recorded native forest and tall tree species and many small trees and bushes; at least 37 recorded fish species and various kinds of other aquatic animals; at least 33 – 107 recorded bird species (including at least 5 globally threatened and many critically endangered, endangered, and vulnerable species of Thailand); at least 29 recorded odonate species; and enormous numbers of species of amphibians, reptiles, mammals, insects, and many other wildlife (Thipaksorn, 1998; Sripen, 1999). The more species diversity is maintained, the more stable the ecosystems are. Populations of rice pests such as rats, insects, mollusks, are controlled naturally within rice fields by natural enemies – predators and parasites. Odonate insects are important predators of rice pests. Birds eat and help reduce insect pests. Birds and ducks help eradicate rice enemies e.g. golden-apple snails. Snakes eat rats. Several native fish species help eliminate rice insect pests. Integrated Pest Management is compatible with integrated rice paddy farming.

Birds and fish excretes help improve paddy soil quality. Patches of native bushes and tall trees maintained within rice paddy fields or surrounding woodlands and swampy areas are nesting and roosting sites of birds. Rice paddy fields have good characteristics for bird conservation, having plenty of foods such as small fish, frogs, shrimps, crabs, snails, shells, snakes, rats, insects, worms, spiders, etc.. Many common residents (e.g. Little Egrets, Cattle Egrets, Little Cormorants, Javan Pond-Herons, Storks, Ducks and Gueese, Rails, Weavers, Kingfishers, etc.) use rice fields as their feeding grounds. Over 41 species of big/tall trees, such as *Crudia chrysantha, Eugenia cumini,* Manila Tamarind *Pithecellobium dulce,* Mango

Mangifera indica, Tamarind *Tamarindus indica, Streblus asper, Bambusa spp., Ficus spp.*, are used as nesting and roosting sites by Asian Open-billed Stork. Excretes of Asian Open-billed Stork is added into rice fields. Each year, rice paddy fields with Asian Open-billed Stork inhabiting tall trees receive extra amount of N, P, K natural fertilizer plus other nutrient minerals like calcium, magnesium, and organic matter. Excretes of Little Cormorants also have high N and P organic fertilizer. Birds' excretes help improve paddy soil fertility and quality.

Densed grasses along paddy bunds and ditches, not only provide habitats for wildlife, but also maintain soil moisture and help prevent soil erosion. Vetiver plant can be grown and used, not only to perform this specific function, but also can be used as livestock forage, insect repellant, insecticide, roof thatch, mushroom cultivation medium, compost, water purification, handicraft material, medicinal applications, and other uses. Many other native plants, for example *Sesbania bispinosa*, if are maintained or grown, can help improve soil quality and enhance soil fertility (http://www.vetiver.org/ ; http://www.worldagroforestry.org).

Many plants in paddy fields are useful. Floating plants such as *Salvinia cucullata* and *Salvinia natans* are considered useful for maintaining lower water temperature in paddies. *Adenosma javanica* and *Ludwigia hyssopifolia* can be used as pig feed. Almost all species can be used as forage for cows and buffaloes. Rice straw can be kept after threshing and used for livestock feeding. Rice husks can be used as feed for chicken, ducks, and fish.

Enhancement of food and health security

Many plants in rice paddy fields are edible and are food plants having high nutritive values, medicinal properties, and useful chemical composition. Collection and consumption of wild food resources, wild plants and medicinal plants from rice paddy fields are important for daily life of many poor rural households. Wild food resources available in different habitats include fish, frogs, crabs, shrimps, snails, birds, snakes, rats, insects, spiders, ant eggs, and many others, as well as wild plants such as herbs, shrubs, vines, trees, and aquatic plants. Many plants are widely used for medicinal purposes. Many plants are used as or used for animal feed, compost and green manure, natural pesticides, soil amendment, household utensils, housing materials, fuel and firewood, and handicrafts.

Rice itself has very high nutritive value and medicinal value. Local traditional doctors in Thailand have used rice as medicine for healing various symptom groups with hundreds of traditional medicinal formula. Many other plants in rice paddy ecosystems contain bio-active substances with potential disease-preventing or health-promoting mechanisms. These include substances having useful quantities of trace-minerals and vitamins to improve body functioning; having potential for therapeutic uses; stimulating the immune systems; having anti-oxidants, antibacterial, antimutagenic, or antiviral activities. An extremely wide range of therapeutic applications of medicinal plants from rice paddy fields include : to relieve fever, pain, sore throat, tiredness, mood depression, apathy, sleeping problems, nausea, dizziness, impaired concentration; against backache, toothache, stomachache, vomiting, discharge; to strengthen bones; to preserve healthy vision; to cure night blindness; to reduce high blood pressure; to reduce swelling; to relieve muscle pain; to augment lactation; to improve digestion; to cure intestinal cramps, intestinal disorder; to improve functions of liver, kidney, lung, heart, brain; to reduce cholesterol; to treat flu, asthma, arthritis, anaemia, diabetes, hyperlipidemia, heart disease, hepatitis, skin diseases, ringworm, dysentery, diarrhea, hemorrhoids, hemorrhage, malaria, irregular menstruation; to heal wounds, burn; to stop bleeding; to relieve uterus infections; as cough medicine, cooling agent, a febrifuge, an expectorant, a diuretic, an anti-oxidant, an antibiotic, an antihistamine, an anti-inflammation, an astringent, a poultice, a decoction for internal ailments, a remedy for insect, scorpion, dog, and snake bites, an anti-herpes; to remove toxin; to remove intestinal parasites; to soften keloids and reduce scars; and many others.

List of some useful plants found in rice paddy ecosystems is compiled and provided below.

More than 48 recorded food plants & food plants with medicinal properties :
Adenanthera pavonina (Red Beadtree); *Alternanthera philoxeroides* (Aligator weed); *Alternanthera sessilis* (Sessile flowered globe amaranth); *Amaranthus viridis* (Slender amaranth); *Azadirachta indica* (Neem tree); *Blyxa japonica; Cassia siamea* (Thai Copper Pod); *Centella asiatica* (Indian Pennywort, Asiatic Pennywort); *Chromolacna odorata* (Bitter Bush, Siam weed); *Cleome gynandra* (Wild spider flower); *Colocasia esculenta*; *Crateva magna*; *Cyperus brevifolius* (Green Kyllinga); *Cyanotis axillaris*; *Diplazium esculentum* (Edible Fern); *Dolichandrone serrulata*; *Eichhornia crassipes* (Water hyacinth); *Emilia sonchifolia* (Lilac Tasselflower); *Eleocharis tuberosa; Glinus oppositifolilus; Ipomoea aquatica* (Morning glory); *Justicia balansae; Kaempferia fallax*; *Kaempferia galanga; Kaempferia larsenii*; *Kaempferia marginata*; *Leucaena leucocephala*; *Limnophila aromatica* (Rice paddy herb, Finger grass, Balloon vine); *Limnophila geoffrayi; Limnophila rugosa*; *Lobelia alsinoides* (Chickweed); *Lygodium sp.; Marsilea crenata* (Clover fern, Water clover); *Melaleuca quinquenervia* (Punk tree, Paperbark tea tree); *Monochoria vaginalis* (Monochoria); *Nelumbo sp.* (Lotus); *Neptunia natans* (Water mimosa); *Neptunia oleracea* (Water mimosa); *Nymphaea sp.* (Water Lily); *Ottelia alismoides*; *Paederia pilifera*; *Scirpus tuberosus; Sesbania grandiflora*; *Sesbania javanica* (Sesbania); *Sesbania roxburghii* (Sesbania); *Smilax sp.; Solanum sanitwongsei*; *Tamarindus indica* (Tamarind)

More than 73 recorded plants with medicinal properties : *Acrachne racemosa; Acrostichum thalictroides*; *Ageratum cynozoides; Amaranthus spinosus* (Spiny amaranth); *Amorphophallus sp.; Apluda mutica; Arundo donax; Basella rubra; Blepharis maderaspatensis*; *Bulbostylis barbata; Calotropis gigantean* (Crown flower, Giant Indian Milkweed); *Cardiospermum halicacabum* (Balloon vine, Heart pea); *Cassia alata* (Golden bush, Ringworm bush); *Cassia tora* (Tora); *Chloris barbata; Commelina diffusa* (Spreading dayflower); *Commelina communis; Crinum amabile*; *Crinum asiaticum*; *Cynodon dactylon*; *Cyperus alternifolius; Cyperus kyllingia; Cyperus malaccensis*; *Cyperus polystachyos*; *Cyperus rotundus* (Purple nutsedge, Nut grass); *Dactyloctenium aegyptium* (Crowfootgrass); *Echinochloa colonum; Eclipta prostrata* (False daisy, White eclipta); *Elephantopus scaber*; *Eleusine indica*; *Enhydra fluctuans; Eragrostis tenella; Eupatorium odoratum; Ficus heterophylla*; *Fimbristylis aestivalis*; *Fimbristylis globulosa* (Lesser fimbristylis); *Fimbristylis miliaces*; *Glinus oppositifolius*; *Hydrocharis dubia* (Frogs bit); *Hygrophila erecta*; *Imperata cylindrica* (Cogongrass); *Ipomoea pes-tigridis*; *Lantana camara*; *Leersia hexandra; Leptochloa chinensis; Limnocharis flava*; *Ludwigia adscendens* (Creeping water primrose); *Monochoria hastata*; *Nymphaea nouchali* (Water lily); *Ottelia alismoides*; *Panicum repens* (Torpedo grass); *Passiflora foetida* (Red fruit passionflower); *Pennisetum pedicellatum; Pennisetum polystachyon; Pentapetes phoenicea*; *Phragmites australis; Pistia stratiotes* (Water lettuce); *Portulaca oleracea* (Pig weed); *Rhinacanthus nasutus*; *Saccharum spontaneum; Sagittalia guayanensis*; *Scirpus articulatus*; *Scirpus erectus; Scirpus grossus*; *Scirpus maritimus; Sclerostachya fusca; Scoparia dulcis; Sesbania bispinosa*; *Sida rhombifolia*; *Sphenoclea zeylanica*; *Spilanthes acmella* (Paracress); *Stachytarpheta jamaicenses* (Brazilian Tea); *Tribulus terrestris* (Ground Bur-nut, Caltrop)
More than 8 recorded natural pesticide/insecticide plants : *Acorus calamus*; *Azadirachta indica* (Neem tree); *Centella asiatica* (Indian Pennywort, Asiatic Pennywort); *Derris elliptica*; *Eclipta prostata*; *Eupatorium odoratum* (Bitter Bush, Siam weed); *Limnophila aromatica* (Finger grass, Balloon vine)(Fungicide); *Stemona tuberosa*
More than 23 recorded plants with functional uses for handicrafts, household utensils, housing materials, fishing gears, firewood, fuel, compost, green manure, ornaments, animal feed, paper-making, toys, and many others : *Alysicarpus vaginaris* (Alyce clover); *Azolla pinnata* (Azolla); *Chara spp.*; *Cyperus compactus*; *Cyperus difformis*; *Cyperus imbricatus*; *Cyperus iria*; *Cyperus pilosus*; *Cyperus procerus*; *Cyperus pulcherrimus* (Elegant cyperus); *Imperata cylindrica* (Cogongrass); *Lemna perpusilla* (Duckweed); *Neyraudia reynaudiana* (False reed); *Nymphoides indica* (Water snowflake); *Saccharum procerum*; *Scirpus erectus*; *Scirpus grossus*; *Scirpus mucronatus*; *Saccharum spontaeum* (Wild Cane); *Sesbania bispinosa*; *Typha angustifolia* (Narrow-leaved cat tail); *Xyris indica* (Yellow-eyed grass); *Echinochloa stagnina*

Sources : http://www.idrc.ca/; Sornlump, P. (http://www.oknation.net : 27/09/10); Navigamun (1993); Matchacheep (1995); Sripen (1999); Prayoonrat (n.d.); Komalamisra et al. (2005); Kosaka et al. (2006); Picheansoonthon and Koonterm (2008)

The above list is only some parts of records derived from a preliminary documentary research and compilation. There is still so much unknown and non-published knowledge about biodiversity and values of rice paddy fields and the best practices of rice farming.

Conclusion

Maintaining biological diversity is essential for productive agriculture and ecologically sustainable agriculture is essential for maintaining biological diversity. Rice paddy fields, the largest manmade wetlands - complex, dynamic and diverse ecosystems, have significant role in biodiversity conservation. Maintaining diversity of native/wild/traditional rice varieties, floral and faunal communities including soil microorganisms and ecological food webs and food chains in rice fields, is therefore significantly important. Integrated rice paddy farming is one of the best practices which demonstrates how people respect and live in harmony with nature. Local traditional wisdom of plant species used, where to collect them, how to collect and prepare them, and how to use them is an important knowledge possessed by local communities. Public healthcare systems could benefit from respecting and incorporating these traditional knowledge.

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