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# SUSTAINABLE AGRICULTURE AND ENVIRONMENTAL PROTECTION IN THE TONLE SAP PLAIN: IMPROVING IWRM AND FARMER PRACTICES[1]

*At present, many farmers must use pesticide to protect their crop, Damnak Ampil Scheme, Pursat Province.*

## Introduction

Cambodia's pan-like topography[2] is conducive to collecting and distributing rainwater across the central area i.e. the wide fertile Tonle Sap plain and the lower and upper Mekong plains, where it feeds agricultural (mainly rice) production. The surrounding plateau and highlands (e.g. Dong Rek Mountains to the north and northwest and Cardamom Mountains to the south and southwest) form 16 large natural catchments (MOWRAM 2011) with a number of rivers and tributaries flowing to the Tonle Sap Great Lake in the centre of the country.

Agriculture is the backbone of Cambodia's economic development, contributing approximately 29 percent to the gross domestic product (GDP) (MAFF 2010:15). The government has made great efforts and capital investments to rehabilitate and develop physical irrigation infrastructure, including canal systems, dams, dykes and water pumping stations, to ensure adequate water delivery for both wet and dry season rice farming (Nang *et al.* 2007). As a result, annual rice production over the last decade has remarkably improved, from 4 million tonnes in 2001 to 8 million tonnes in 2010 (MAFF 2010: 19).

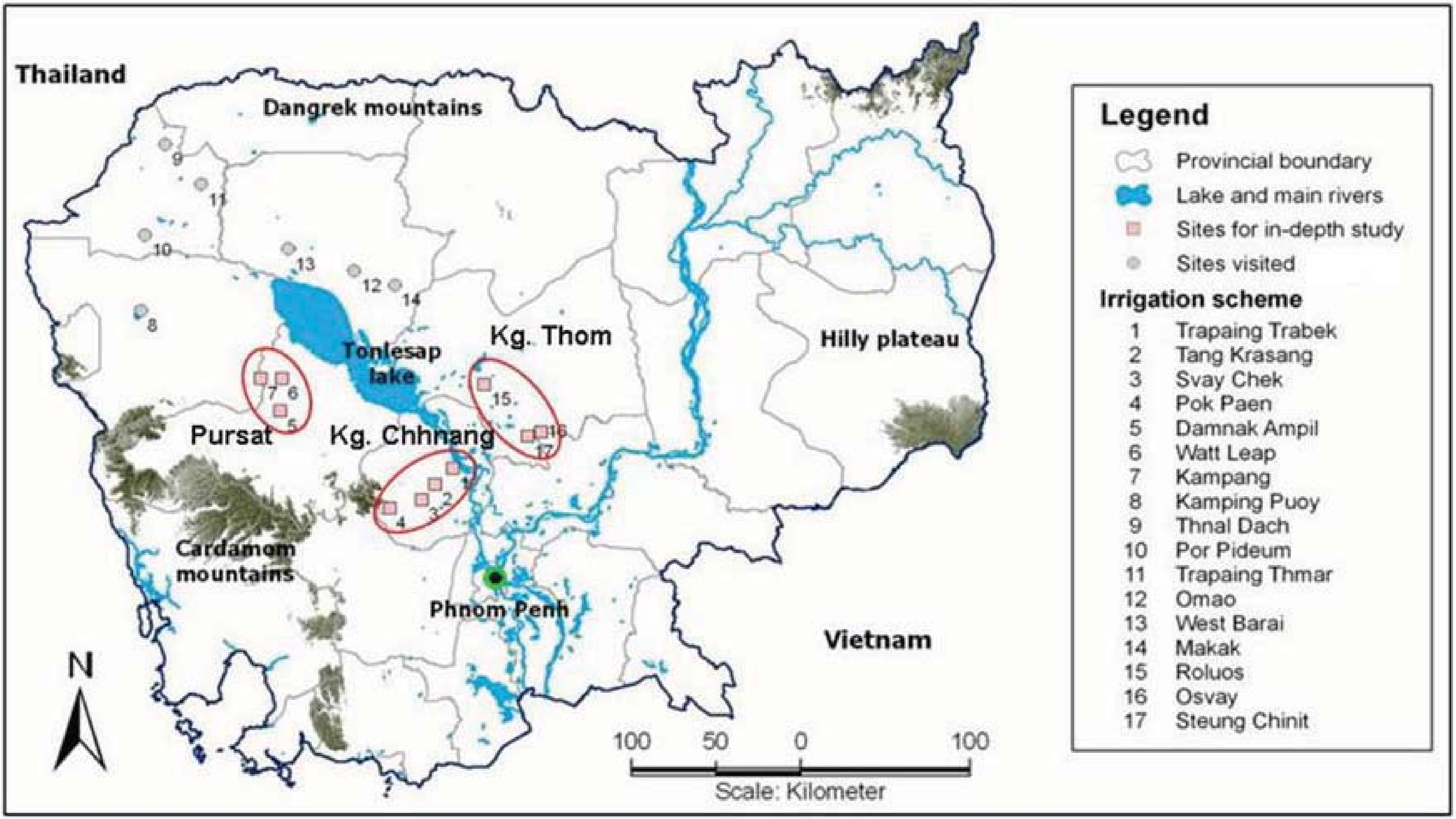
Loss of tree cover, due to the conversion of forest areas in the catchments for economic development, and increasing chemical fertiliser use to boost yields, both of which have led to land degradation and diminished agricultural productivity, have prompted many institutions to reconsider the way forward for agricultural development and sustainable natural resource management so as to ensure long term

1 This article is prepared by Nang Phirun and Ros Bansok, research associates, and Ouch Chhuong, research assistant, at CDRI.

2 Known as the central low-lying alluvial plain.

## In This Issue

Figure 1: Map of Study Areas




Source: Yem 2009

Table 1: Average Rice Yield and Fertiliser Use

| Items | Wet 2008 | Dry 2008/09* | Wet 2009 | Dry 2009/10** |
|---|---|---|---|---|
| Number of HHs | 205 | 55 | 205 | 55 |
| Average yield (tonnes) per ha | 1.6 | 3.2 | 1.6 | 3.7 |
| Average fertiliser use (kg) per ha | 68 | 80 | 174 | 194 |

Note:* November 2008 to March 2009; ** November 2009 to March 2010

benefits. The Ministry of Agriculture, Forestry and Fisheries (MAFF 2011) points out that forest cover declined by about 16.1 percent between 1965 and 2010, while degradation of the watershed and increased fertiliser and pesticide use have led to increasing sedimentation and decreasing water quality of the Tonle Sap Lake. That fertiliser import has almost doubled from 60-80 thousand tonnes in 1998 to 120-140 thousand tonnes in 2008 to some extent reflects the growing use of chemical farming inputs (MOE 2010).

The aim of this study is to examine rice farming practices and assess the trend of chemical fertiliser use in ten irrigation schemes in three provinces around the Tonle Sap Lake. Consistent with the principles of Integrated Water Resources Management (IWRM) set out in the 2007 Water Law (MOWRAM 2007) and the concept of sustainable agricultural development, the study also seeks practicable measures and opportunities to improve rice production while minimising potential adverse impacts on natural resources and the environment, especially land productivity, water quality, aquatic resources and human health and welfare.

## Analytical Approach and Scope of the Report

Empirical agricultural data on rice yield, fertiliser use (particularly chemical fertiliser), water resources management and allocation, land use management and farming practices of 205 selected households in ten main irrigation schemes[3] in Kompong Chhnang, Kompong Thom and Pursat provinces (see Figure 1) were collected and analysed to identify the current and future trends of rice production and fertiliser (particularly inorganic fertiliser) use.

The substantial data and information collected from farmers, farmer water user communities (FWUC), local authorities and provincial departments of water resources and meteorology (PDOWRAM) and agriculture, forestry and fishery (PDAFF) and analytical results were used to examine the possible effects resulting from the amount of inputs used in rice cultivation and the challenges these could pose to water resources management, and to identify pragmatic mechanisms that would ensure the environmentally sound use of chemical inputs for improved rice production. Issues related to land degradation due to economic development in the watershed areas, however, are outside the scope of this study.

## Challenges to Rice Production Improvement

### *Rice Production*

Farmers usually choose good quality seed for wet and dry season rice cultivation. There are several rice seed varieties. Many farmers opt for the new early maturing (90-100 days) strains of rice which consume little water.

All of the 205 households (HHs) selected for the survey engage in wet season rice farming and only 55 cultivate dry season rice. The wet season cultivated area is about 420 ha, of which 120 ha is suitable for dry season rice farming. Individual household cultivated areas (rice plots) range from less than 0.5 to 8 ha

Table 1 shows that from 2008 to 2010, average wet season rice yield remained constant, i.e. 1.6 tonnes per ha, and dry season rice yield increased by about 0.5 tonnes per ha.

Rice farming is the major agricultural activity in all the study sites. Most farmers use traditional farming methods which, alongside ineffective farming techniques and lack of irrigation infrastructure, keep farmers' rice yields low. Persistently low yields and the high demand for irrigation systems reflect the significant scope for rice farming development in the study areas.

3 Damnak Ampil, Kampang, Wat Leap and Trapeang Trabek schemes are located in Kompong Chhnang province, Taing Krasaing, Svay Chek and Pok Pen schemes are in Kompong Thom province and Rolous, Chinit and O' Svay schemes are in Pursat province.

### *Fertiliser Consumption and Trends*

Farmers apply many kinds of fertiliser which are available on the market; however, NPK[4] is most commonly used. Fertiliser is generally applied two or three times during crop growth, the amount depending on what farmers can afford and when, rather than on the quality or type of fertiliser and soil and crop requirements. The first application entails phosphate (66 percent) and urea (28 percent) fertilisers, the second involves urea (60 percent), phosphate (28 percent) and nitrate (about 7 percent), and the third is made up of urea (40 percent) and other locally made organic fertilisers[5] (40 percent). Average annual fertiliser use is 129 kg per ha (see table 1 above).

The amount of fertiliser used in rice farming has remarkably increased, from 80 kg per ha in 2008/09 to 194 kg per ha in 2009/10 in the dry season, and from 68 kg per ha in 2008 to 174 kg per ha in 2009 in the wet season (Table 1). Farmers in all of the study schemes increasingly believe that agricultural production can be improved by using more inputs. But while fertiliser adds nutrients to soil, over-fertilisation with a vital nutrient (N, P or K) can be as detrimental to soil and crops as under-fertilisation. Farmers also reported the problem of soil infertility in some rice plots as a result of applying too much fertiliser (at rates of about 300-500 kg per ha); the plots have had to be left fallow for one to three months, depending on soil type, to allow the soil to regain normal productivity.

Farmers are using more fertiliser at higher application rates, yet soil and crop nutrient deficiencies remain prevalent (Bell *et al.* 2004). Fertiliser burn can occur if too much is applied, resulting in a drying out of the roots and damage or even death of the plant (Ecochem 2011). MAFF reports that excessive and inappropriate use of agricultural chemicals over the last two decades has adversely impacted on the environment and human health (MAFF 2006: 21). This reflects that the environmental impact of agro-chemical use remains an important issue and requires remedial actions.

4 "N" stands for Nitrogen, "P" for Phosphate and "K", for Potash.

5 Cattle manure, cereal, legume and woodland litter are commonly used as organic fertilisers.

## Farmer Practices and Options toward Sustainable Agriculture

### *Land Management*

About 64 percent of the cultivated land in the study sites falls within the alluvial plains of the Tonle Sap Basin. This land type is flat, the soil is fertile with low to moderate permeability and the land slope is ideal for gravity-fed irrigation, characteristics which are favourable to both wet and dry season rice cultivation. However, rice fields are mostly small and not at the same level, and in some areas there are no small dykes around them. This makes it difficult to maintain water and fertilisers in the rice paddies. Some farmers complained of water flowing from their rice fields to those of the adjacent farmers', taking the fertiliser they had applied to their crop with it and resulting in lost time, labour, and money spent on fertiliser, and decreased rice yield. If farmers were to cooperate to join their rice plots so they are less fragmented and level the land, nutrients and water could be better distributed and the total yield would be higher. Building small dykes would also ensure effective fertiliser application and water management.

Land management and supporting agricultural extension services are the most effective tools to meet the government's development priority needs (CIDA 2009), as evidenced in the Stung Chinit scheme where the rice fields had been levelled and rearranged into about 46 blocks of 40-100 ha with canal and drainage systems to ensure effective water delivery and discharge throughout the irrigated area. The results from the regression analysis indicate that a rice crop grown on a plot of 0.5-1 ha could produce a yield of around 2-4 tonnes if fertilisers are applied at the recommended rates introduced by agricultural extension staff working in their respective areas. To ensure robust crop yields, effective irrigation, and economical and effective fertiliser use, farmers must also prepare and tend their land properly.

### *Improving Fertiliser Application*

Most of the farmers in the study areas said that they have had no training on how to use chemical fertilisers or how to balance the three major nutrients N-P-K, and the little they did know had been learned from their neighbours. During the FGDs and interviews, farmers revealed that they just follow and copy what other farmers do. High rates of fertiliser application can lead to increased leaching of nitrates into groundwater which makes its way into canals, rivers and lakes where excessive nitrate residues cause eutrophication, i.e. accelerate the growth of algae, disrupt the normal functioning of water ecosystems, poison and kill fish[6].

Only a few of the surveyed farmers in Kompong Thom and Pursat provinces had attended a training course on integrated pest management (IPM) delivered by MAFF and PDAFF agricultural extension staff[7]. When questioned about fertiliser use, farmers said they had learned how to make organic fertiliser i.e. compost and manure, but because it is slow to take effect compared to chemical fertiliser, they no longer use it. This suggests a need for more training among farmers and other stakeholders on how to properly and effectively apply pesticide and fertiliser.

## *Improving IWRM Application*

### *Expand Access to Water*

In the last ten years, the government has renewed efforts and invested in a number of technical programmes aimed at minimising farmers' dependence on rain countrywide. However, the proportion of irrigated land in the study sites is still low. Water storage capacity for dry season farming is limited. Farmers can access irrigation water either through customary or legal rights. The Farmer Water User Community (FWUC) has been established to mobilise water services to farmers. The costs of irrigation scheme operation and maintenance are supposedly covered by the set (per ha) Irrigation Service Fee paid by farmer water users. However, the fee is usually neither paid nor collected (except in the Stung Chinit scheme) since most farmers claim that access to water should be free of charge. This makes it difficult to improve water allocation in the schemes since the available resources for renovating, extending or building new irrigation infrastructures cannot meet actual demand.

Recognising the need for greater community participation to improve the performance of irrigation systems, the Participatory Irrigation Management and Development (PIMD) policy[8] has been integrated into the IWRM framework where it forms a critical component of the national policy to promote farmers' participation in the running and management of irrigation schemes. The irrigation service fee charged to farmers contributes to and helps ensure water delivery and sustain the operation and maintenance (O&M) of the irrigation schemes.

### *Improve Crop Production and Farmer Livelihoods*

Land and water resources and their effective use and management are extremely important for agricultural improvement and rural development in Cambodia. Despite the abundance of water in the wet season, insufficient irrigation infrastructure to harvest and store water for the agricultural sector has led to water supply shortages, especially for dry season farming. Most farmers depend on rain water for wet season cropping. Only some farmers that have access to irrigation water can engage in both wet and dry season cropping.

Of the ten study schemes, Stung Chinit is the only one that has appropriate irrigation infrastructure and well-structured water governance. The remaining nine schemes commonly comprise a water gate or sluice and just a few main canals, leaving most of the rice fields in the study areas beyond the reach of irrigation water. Further, about 21 percent of the surveyed households have to use diesel engine pumps to water their fields. To this end, the government's and other stakeholders' efforts in rehabilitating and developing irrigation infrastructures prioritise improved and effective water management. The government's plan to expand the irrigated area by about 50,000 ha per year is set out in the National Water Policy (MOWRAM 2009: 8).

### *Improve Water Governance Performance*

Present water governance is challenged by the lack of effective feedback mechanisms and coordination among the different levels of government. As stipulated in the PIMD policy, FWUCs are mandated the responsibility for the irrigation schemes' O&M

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6 This process may cause water to become cloudy and/or discolored i.e. green, yellow, brown or red.

7 Two training courses on fertiliser application were organised by MAFF and PDFF in 2011, one in Kompong Chhnang and the other in Kompong Thom province. These were attended by farmers, fertiliser sellers and other stakeholders involved in agricultural products (particularly fertiliser and pesticide) consumption or distribution.

8 Based on a presentation handout at the National Workshop on "Lessons Learned and Resolutions on PIMD", organised by CEDAC at Phnom Penh Hotel on 17 December 2009.

and water allocation and management with strong coordination between up- and down-stream water users. Moreover, FWUCs play an important role as a dynamic network for improving the function of vertical governance mechanisms, linking central government, provincial and local authorities and villages as well as horizontal governance mechanisms that support decision-making across different provincial line departments and commune and village level authorities. Likewise, these same mechanisms positively strengthen FWUCs' performance in water governance.

*Land Water Resources Management and Environmental Protection*

The IWRM framework requires integrated action by players from various sectors, including farmers, FWUCs, local authorities, research centres, government ministries and the pirate sector, to achieve sustainable land and water management while protecting the environment. This approach would raise actors' awareness of the needs and the benefits of environmental protection through both bottom-up and top-down processes so that environmental conservation considerations such as sub-sector competition and perspectives on protecting upper catchments, pollution control and environmental flows are harmonised and well integrated in planning and decision-making. FWUC committees and members would have the opportunity to learn and apply appropriate farming strategies and methods, such as the introduction and selection of suitable rice varieties, soil conservation and land husbandry practices. They can also benefit from soil fertility and pest management programmes so as to improve their agricultural production and improve, rehabilitate and conserve land productivity and water resources.

## Conclusion

Achieving sustainable agricultural development is one of the greatest challenges for many countries worldwide since it implies not only securing a sustained food supply, but also maintaining and protecting the surrounding environment while taking into account socio-economic and human health impacts. This concept is gaining increasing acceptance and being addressed significantly by the global agricultural community (Gold 2007). Improving the adoption of IWRM would ensure that land and water resources degradation due to unsustainable agricultural practices is addressed. This tool would also ensure that those resources will be no longer depredated; instead their productivity will be maintained, protected and restored to provide long term essential goods and services (Torkil 2004).

The findings suggest that both dry and wet season rice yields did not remarkably increase even though the amount of fertiliser applied has more than doubled. As stated earlier, over-fertilisation without well-informed technical knowledge and environmental consideration will adversely affect rice production and land productivity and likely lead to eutrophication. Optimising local skills and technology to achieve long-term stable yields, environment protection and consumer safety would ensure sustainable agriculture. Effective land and water management that draws on the IWRM framework and the PIMD policy would avoid wasting expensive fertilisers and the potential costs of cleaning up any pollution created as a by product of farming (Ecochem 2011). A well-structured FWUC committee, enthusiastic participation of farmers, paddy field management, agricultural extension service accessibility, sufficient canal and drainage systems, water availability after the rehabilitation and development of irrigation schemes and improved cropping practices can provide better yields to farmers, as evident in the effective application of the IWRM and PIMD in the Stung Chinit scheme. It follows then, that land, water and fertiliser management programmes should be put in place to respond to the problems and challenges faced by farmers in most of the study areas. A catchment conservation plan should be designed and implemented and soil and water quality should be monitored regularly to ensure balanced nutrient enrichment of land and water.

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