Coastal Adaptation and Resilience Planning Component

Vulnerability of existing agricultural practices

Cambodia Climate Change Alliance (CCCA)

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Vulnerability of existing agricultural practices

Working paper prepared by DHI under the
Coastal Adaptation and Resilience Planning (CARP) Component,
Cambodia Climate Change Alliance

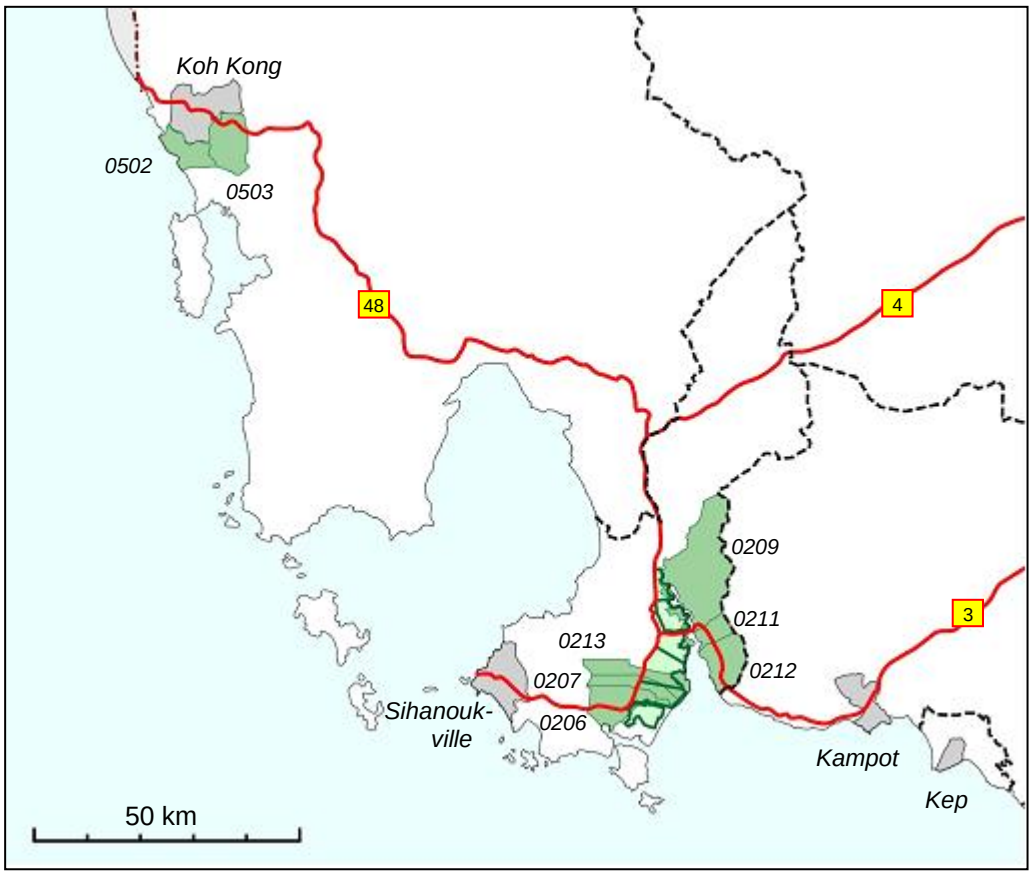
July 2012

Contents

Acronyms and abbreviations

CARP:	Coastal Adaptation and Resilience Planning
CBNRM:	Community-based natural resource management (a concept, and also a name of a network)
CC:	Climate change
CCCA:	Cambodia Climate Change Alliance
CR:	Climate resilience
DOA:	Department of Agriculture
DOE:	Department of Environment
DOWRAM:	Department of Water Resources and Meteorology
EIA:	Environmental impacts assessment
FWUC:	Farmers water users community (water user group)
GIS:	Geographic information system
IDRC:	International Development Research Centre
KK:	Koh Kong
LT:	Long-term (rice variety)
MOE:	Ministry of Environment
MOWRAM:	Ministry of Water Resources and Meteorology
MT:	Medium-term (rice variety)
SHV:	Sihanoukville
ST:	Short-term (rice variety)

Location map



48 Road
National border
Province border
Town
Commune
Polder

Communes:	0502:	Peam Krasaob Commune, Mondol Seima District
	0503:	Tuol Kokir Commune, Mondol Seima District
	0206:	Ou Oknha Heng Commune, Prey Nob District
	0207:	Prey Nob Commune, Prey Nob District
	0209:	Sameakki Commune, Prey Nob District
	0211:	Tuek L'ak Commune, Prey Nob District
	0212:	Tuek Thla Commune, Prey Nob District
	0213:	Tuol Totueng Commune, Prey Nob District

Map compiled from different sources.
Administrative borders, commune codes and English spelling of names are from NIS (March 2012)

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In Koh Kong

Mr. Ben Vanna, Deputy Governor, Mondul Seima District; mr. Chey Yoen, community member, Peam Krasaob Commune; mr. Chhiv Reth, Vice Chief, Fisheries Office; mr. Chut Tit, Commune Chief and Community Chief, Peam Krasaob Commune; mr. Em Yoen, community member, Peam Krasaob Commune; mr. Ev Vanna, Deputy Director, DOWRAM; mr. Hun Marady, Deputy Director, DOE; mr. Khoem Sanith, First Vice Chief, Toul Kokir Commune; mr. Leng Chan Sokthear, Officer, Agronomy Office; mr. Moun Phala, Acting Director, DOE; ms. Neang Kun, First Vice Chief, Peam Krasaob Commune; mr. Phong Livireak, Director, DOA; mr. Prark Dina, Commune Secretary, Toul Kokir Commune; mr. Seng Bunna, Officer, Fisheries Office; mr. Siak Samoun, Vice Community Chief, Peam Krasaob Commune; mr. Som Chea, Deputy Director, DRD; mr. Soun Noun, Chief of Veterinary Office, DOA; mr. Ty Vech, Commune Secretary, Peam Krasaob Commune; and mr. Yem Yan, Vice Chief, Peam Krasaob Commune.

Summary

This study has covered several communes in Prey Nob District, Preah Sihanouk Province; the Prey Nob Polders as such; and Peam Krasaob and Tuol Kokir Communes, Mondol Seima District, Koh Kong Province.

A number of threats are either directly climate-related or will interact with climate-related threats. Examples include *sea level rise* (in some places interacting with *land subsidence)* (affecting cultivation, flood exposure, drainage and coast erosion); *sea water intrusion* (affecting water availability for cultivation and other purposes); *increased frequency of storms* (affecting cultivation, fisheries and coast erosion); and *degrading soil quality* (affecting cultivation). *Drought* is a minor concern today (unlike in the rest of the country) but can escalate if the weather gets more irregular, in which case the area will be particularly vulnerable (due to lack of local experience). Between them, these threats will negatively affect the prospects for sustainable livelihoods.

A long-list of potential pilot projects and demonstration activities has been compiled for further consideration. Examples, listed in random order, are:

General support to production systems and livelihoods: Formation/consolidation of farmer and fishery communities; and technical support directly to farmer households.

Activities in Ou Oknha Heng, Prey Nob and Tuol Totueng Communes and the Prey Nob polder area: A tree-planting scheme, to break the wind (such a demonstration activity could provide a useful example for replication elsewhere); a feasibility assessment of a compartmentalization of the polders (to confine exposure to sea water intrusion) (with due attention to the drainage implications); and systematic monitoring of salinity and land subsidence.

Activities in Sameakki, Tuek L'ak and Tuek Thla Communes, Preah Sihanouk: Support to appropriate use of fertilizer and pesticides; promotion of better seeds, particularly high-yield short-term rice varieties; and support to various supplementary livelihoods.

Activities in Tuol Kokir Commune, Koh Kong: A major agricultural pilot and demonstration programme. The area reaches across high and low exposure to sea water intrusion. The farmers are innovative (more than 10 seed varieties are used), and the DoA is active in providing guidance. The area could serve as a *'controlled laboratory'* for identification of appropriate seeds and cultivation practices, testing various options side by side. The participating farmers should be secured against economic risks. Such an activity could provide highly useful knowledge to other coastal areas within and outside Cambodia, provided that results are duly disseminated.

Other activities in Peam Krasaob and Tuol Kokir Communes, Koh Kong: Support to dissemination and promotion of recent, apparently positive experience with two crops per year; appropriate land use and soil management in areas next to the mangroves (part of which are in a state of rapid deterioration).

1 Introduction

This paper is related to Outcome 2 of the CARP: *'Increased resilience of coastal communities and coastal ecosystem buffers to climate change and improved livelihoods'.*

Specifically, it is related to Output 2.4:

> *'A review analysis of the vulnerability of existing agricultural practices to the impacts of climate variability and climate change'.*

The work included a series of consultations with government bodies, farmers, fishermen and others in Preah Sihanouk and Koh Kong in May and June 2012.

For a more comprehensive analysis related to CARP Output 2.4, please refer to *'Assessment of community vulnerability and risks from climate change in the coastal zone of Cambodia'* (DHI June 2012).

An assessment of Implementation capacity of demonstration activities is being prepared as a separate document, together with suggestions on capacity-building activities, some of which may be considered as pilot projects/demonstration activities in their own right.

2 Background

Demonstration sites have been selected as follows:

- Ou Oknha Heng, Prey Nob and Tuol Totueng Communes (covering parts of the Prey Nob Polder), as well as Sameakki Tuek L'ak and Tuek Thla Communes, all in Prey Nob District, Preah Sihanouk Province; and
- Peam Krasaob Commune and Tuol Kokir Commune, Mondol Seima District, Koh Kong Province.

Large parts of these areas have low elevations above sea level and a particular vulnerability to climate change. They feature agriculture (mostly paddy cultivation); fisheries (mostly small-scale); and mangrove ecosystems.

The selection of these two provinces was endorsed by the stakeholders present at the national consultation workshop on 16 March 2010 which included stakeholders from all provinces. [1]

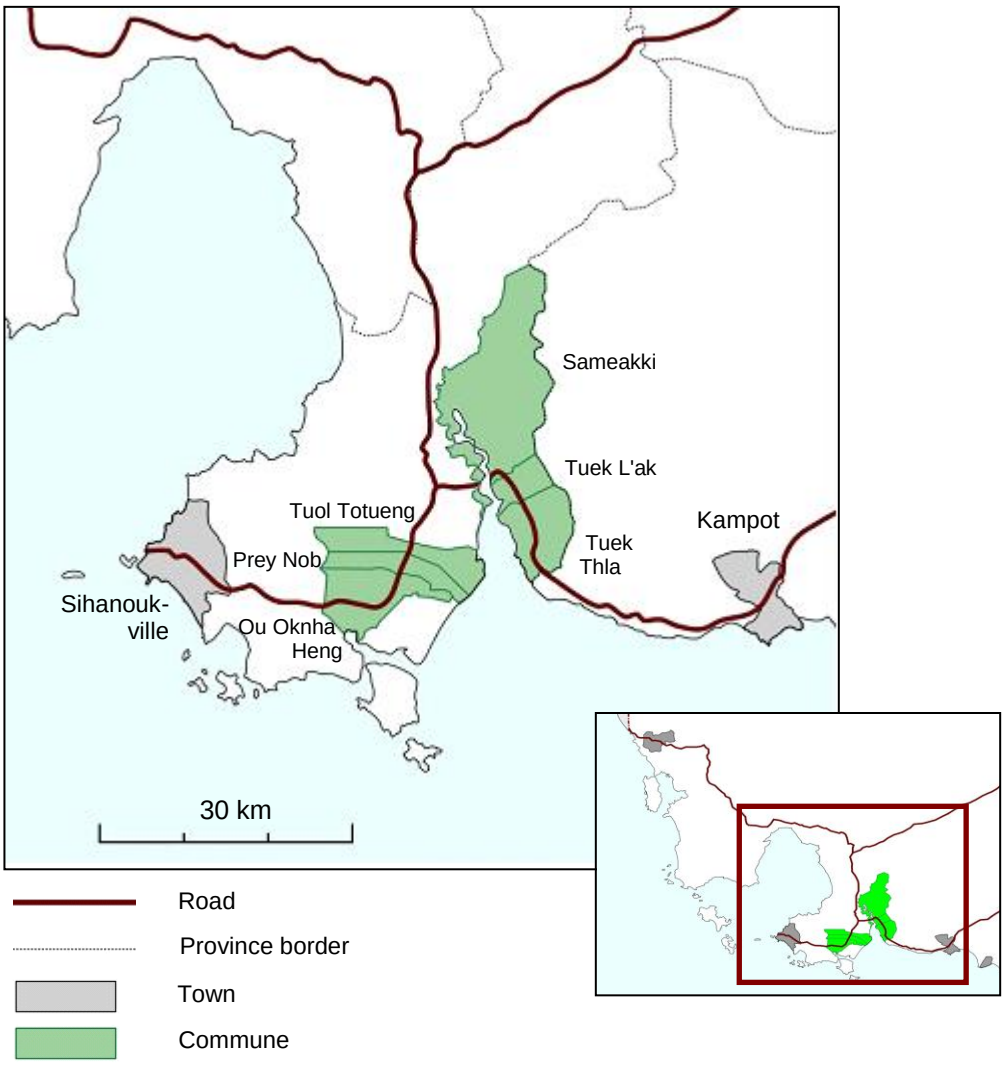
The areas represent frontiers in Cambodia's exposure to climate change. Lessons learnt and achievements made would serve as examples for replication elsewhere in Cambodia, as well as in other countries.

[1] DHI September 2011

3 Resource-based livelihoods

3.1 Pilot communes in Preah Sihanouk

Figure 1: Pilot communes in Preah Sihanouk Province



Cultivation

One rainfed crop of rice is grown per year. Yields are below the district average of 1.8 t/ha and well below the province average of 2.2 t/ha (which is in turn below the national wet season average of 2.3 t/ha). The yield is a bit better in parts of the polders, and in Sameakki, which are less exposed to sea water intrusion.

Table 1: Cultivation and livestock

Commune	Land holdings	Yield	Livestock
Ou Oknha Heng	0.5-3 ha, average 0.6 ha	2.7 t/ha	377 buffaloes, 491 cows
Prey Nob	Up to 5 ha, average 1.5 ha	2.7 t/ha	187 buffaloes, 104 cows
Tuol Totueng	Up to 4 ha, average 1.5 ha	2.6 t/ha	67 buffaloes, 108 cows
Sameakki	0.5-3 ha, average 1 ha	1.7 t/ha	1,200 heads, mostly buffaloes
Tuek L'ak	Up to 1 ha, average 0.5 ha	1.5 t/ha	912 heads, mostly cows
Tuek Thla	Up to 1 ha, average 0.5 ha	1.5 t/ha	859 heads, mostly cows

Source: Information from district and commune representatives (May and June 2012)

Seeds are retained from year to year. A distinction is made between three types, named after the colour of the grains: Red and white (for eating) and brown (for sweets). These are rotated year by year.

Many farmers sow the rice directly. As compared with transplanted rice, this can shorten the cultivation period by around a week time (a priority in this area), but the sensitivity to drought (if any) early in the cultivation cycle becomes higher (less of a concern in this area). Also, the yield will be somewhat less.

Table 2: Types of rice grown (percent of area in each commune)

Variety	Transplanting	Harvest	White	Red	Brown
Ou Oknha Heng 1)					
ST	Early July	Early October		5%	
MT	Early July	Early November	30%	60%	5%
Prey Nob 2)					
ST	Early July	Late October	5%	5%	
MT	Early August	Early December	30%	60%	
Tuol Totueng 3)					
LT	Early July	Early December	35%	65%	
Sameakki, Tuek L'ak and Tuek Thla					
ST	Late June	Early October 4)		16%	
MT	Late June	Late October 4)	15%	56%	5%
LT	Late June	Late November 4)		8%	

1): 70% of farmers sow the rice directly in late May (without transplanting)

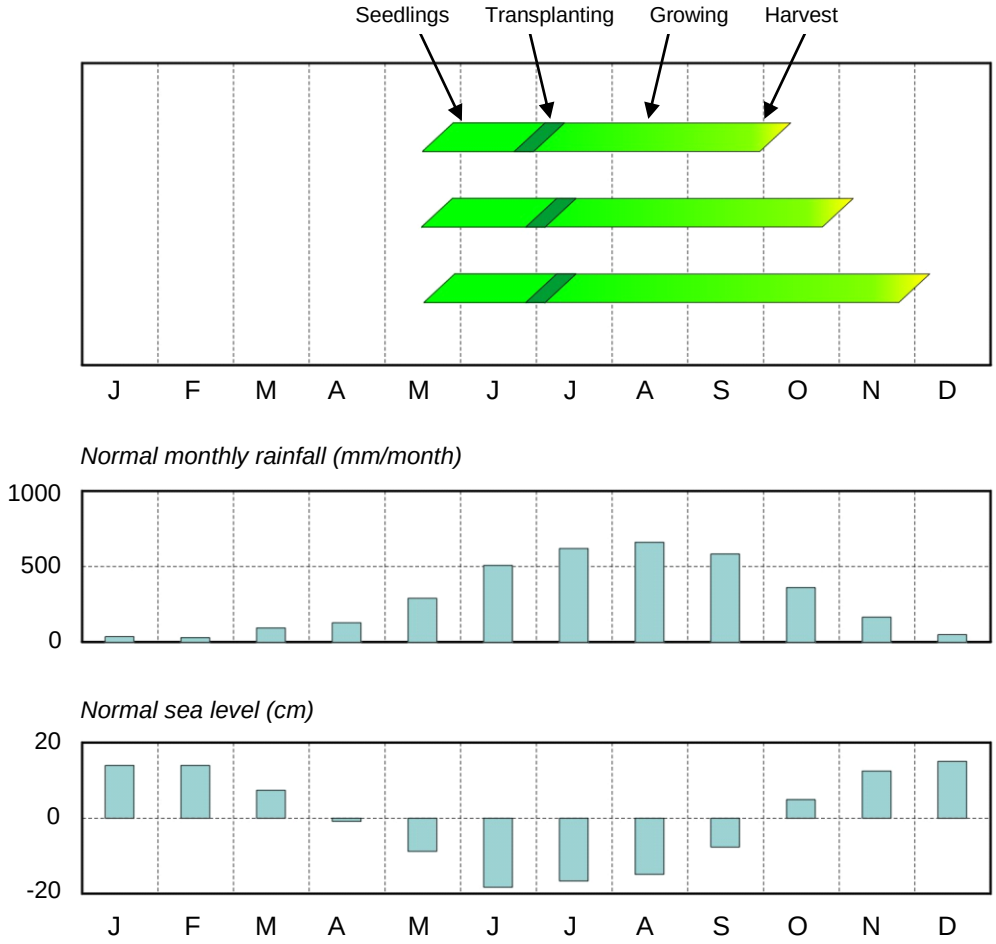
1): 50% of farmers sow the rice directly in late May (without transplanting)

3): 80% of farmers sow the rice directly in late May (without transplanting)

4): Or later, depending on soil conditions

Source: Information from district and commune representatives (May and June 2012)

Figure 2: Typical cropping cycles in Prey Nob District



Some supplementary crops are grown for household consumption and (sometimes) for sale, for example winter melon and cucumber. Maize and long beans could be grown if more water is available. Livestock includes buffaloes, cows, pigs, chicken and ducks.

Figure 3: A healthy pig in Toul Village, Tuek L'ak Commune

Aquaculture

Aquaculture is practised to a minor extent only (202 households in the whole district). The reason why it is not more common is that capital and operating costs are high as compared with the income. Also, technical skills are limited.

Issues

Impediments include:

- Small yields and small land holdings
- Sea water intrusion, gradually declining from south towards north
- Storms damaging the crops (particularly the MT crops, while ST crops are already harvested, and LT crops are somewhat more robust). This occurs almost every year from mid October and through December
- Soil degradation caused by inorganic fertilizers
- Inappropriate use of pesticides (partly due to lack of instructions from the manufacturers), causing fish deaths and (sometimes) human sickness (as well as, presumably, unnecessary environmental pollution).

3.2 The Prey Nob Polders

General

The polders cover parts of Ou Oknha Heng, Prey Nob and Tuol Totueng Communes, as well as parts of several other communes in Prey Nob District.

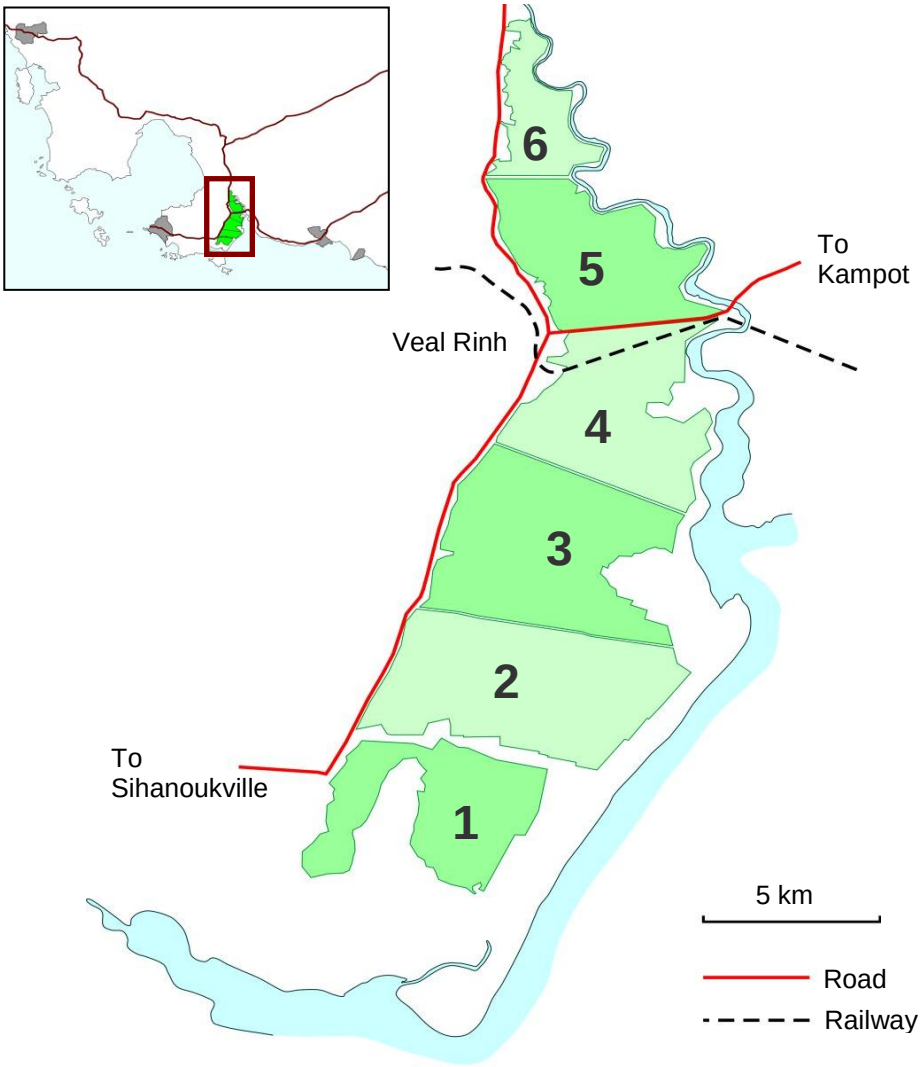
This is the only irrigated area in Preah Sihanouk Province (and still predominantly rainfed). A limited volume of water can be retained in a number of small ponds, and in canals within the area.

The system consists of 6 polders, sharing 90 km of dykes, 125 km of canals and 36 auto sluice gates. Between them they cover an area of 10,500 ha.

The system is threatened by sea water intrusion due to its low elevation. The two northernmost polders (nos. 5 and 6) suffer critically from rain-generated floods, due to low drainage capacity.

The elevation of the area is just around annual mean sea level. The water management is a delicate balance between keeping the sea water out (when the sea level is high) and disposal of the surface runoff by gravity flow (when the sea level is low).

Figure 4: The Prey Nob polders



History

1930-70: Polders 1-5 constructed

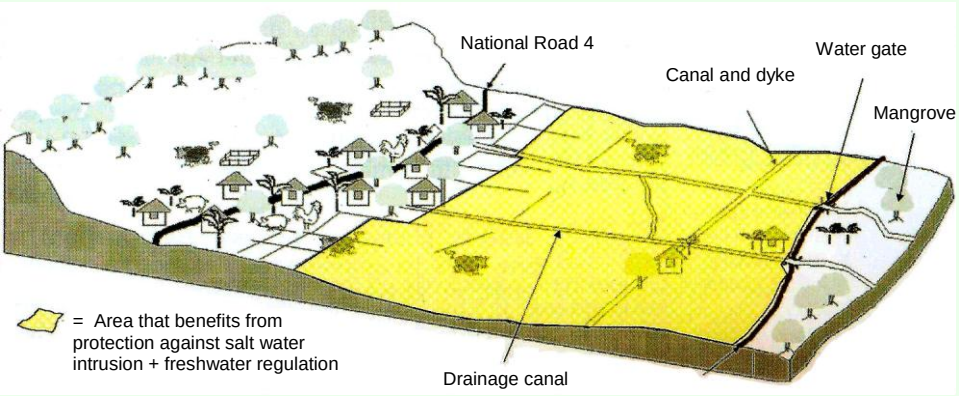
1998-2001: Polders 1-4 rehabilitated

2000-04: Polder 5 rehabilitated, Polder 6 constructed

Tourism

The polders are listed in the Total Road and Tourist Atlas (Gascuel, September 2009), see text box below. They have a good location, next to National Road 4 and not far from Sihanoukville.

The Prey Nob polders as a tourist destination



'13 km after the Ream junction, in Kokir, National Road 4 heads north. From there, over 12 km on the right of the road until Prey Nob, ***the water dykes at Prey Nob:*** *More than 100 km of dykes protect 11,000 ha of rice fields from being flooded by salt water from the sea. This place inspired Marguerite Duras for her novel 'The Sea Wall'. A memorial stone is displayed here. The water dykes, which can be seen, are themselves from a project that originally started in 1927 and was rehabilitated by France in 1998 until 2005. 800,000 m3 of earth has been moved, 30 concrete structures built, water gates and pipes, resting on thousands of wooden piles'.*

Quoted from the Total Road and Tourism Atlas 2009/10 (Gascuel, September 2009)

Cultivation

The polders provide 10,500 ha of paddy fields. One rainfed crop is grown per year, mostly MT, but also some ST. Yields can be up to 3 t/ha for fields far from the sea. Seeds are retained from year to year.

Land holdings are small - mostly less than 1 ha. Most farmers own their own land.

Management

The outer dyke (and the main defence against sea water intrusion) is managed by MOWRAM. Other structures (canals and gates) are managed by a polder water user community (FWUC). [2]

The FWUC serves more than 6,000 households (some 15,600 persons) in 43 villages in 11 communes. It employs 6 persons at the centre and 43 in the villages.

Farmers pay 12.50 USD per ha per year to the FWUC for operation and maintenance.[3] [4]

Good technical documentation is available.[5]

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2 This is the only FWUC in the province at present. One more is in the works, covering another area exposed to sea water intrusion

3 Another source says around 15 USD per ha per year

4 The payment is made for around 8,500 ha. (The areas of the polders are a bit a matter of definition, since some of them are partly delineated by dykes and partly by elevated lands where there is no need of dykes)

5 This is sometimes not the case elsewhere in the country

Figure 5: The Prey Nob Polder FWUC

Issues

Land subsidence is a major concern, given the low elevation of the area relative to the sea. Parts of the area subsided by 5-7 cm/year from 2001 to 2007. The main dam has subsided by 0.8 m at places, and its crest level is now around the annual high sea level[6].

Storm water drainage is needed for cultivation, for example during rice harvest. Once the area has subsided a bit more than today, drainage will require pumping of large volumes (although against a low pressure head). This is technically straightforward, but the construction and operation costs are a matter of concern as compared with the achievable economic benefits.

Storm water disposal is affecting adjacent lands (north and east of the polders) during heavy rain, when the flood gates of the polders are opened. This is possibly amplified by small, private polders outside the area, but no clear information is available.

Weather irregularities cause flooding or sea water intrusion. In late September 2011 there was 140 mm rain in 12 hours. Storm surges occur occasionally, typically in late September/early October.

Small land holdings and small yields make it difficult for the households to make ends meet.

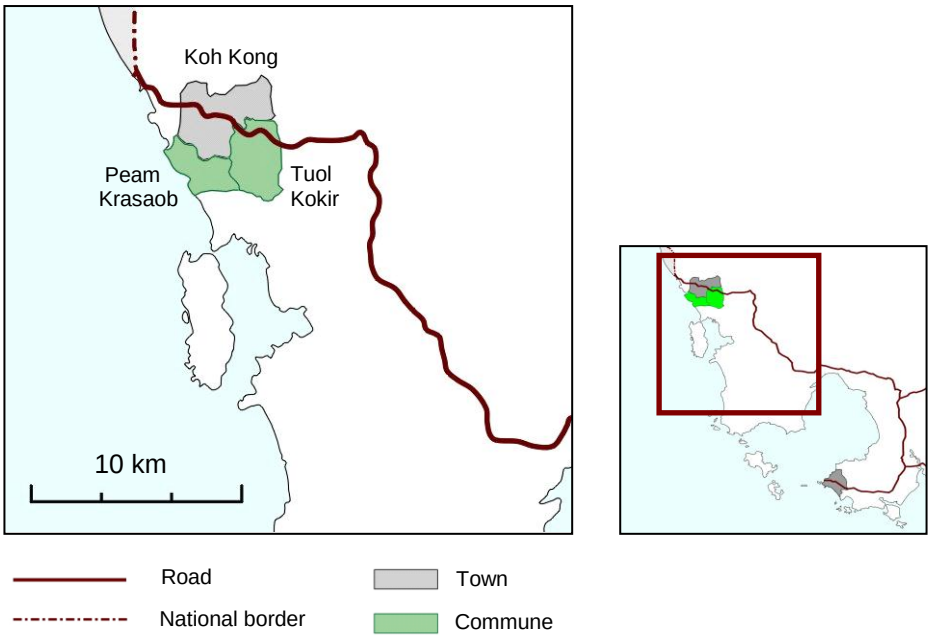
Lack of data and information, and access to existing data and information are serious constraints. Knowledge is needed (about for example normal and extreme rainfall, normal and extreme sea level, sunlight radiation, and time and space distribution of sea water intrusion) for appropriate choices related to selection of rice varieties and

6 Detailed data have not been accessed at this stage. Records of seasonal and extreme sea levels would expectedly be available, possibly from the harbour authorities. Some specific information about subsidence rates exists but has not been retrieved

cultivation modalities. Without such knowledge, innovation becomes a search in the dark for small-scale farmers with no capacity for uncertainties and risks. Some farmers try to learn (and import seeds) from families and friends elsewhere in Cambodia, where conditions are quite different.

3.3 Pilot communes in Koh Kong

Figure 6: Pilot communes in Koh Kong Province



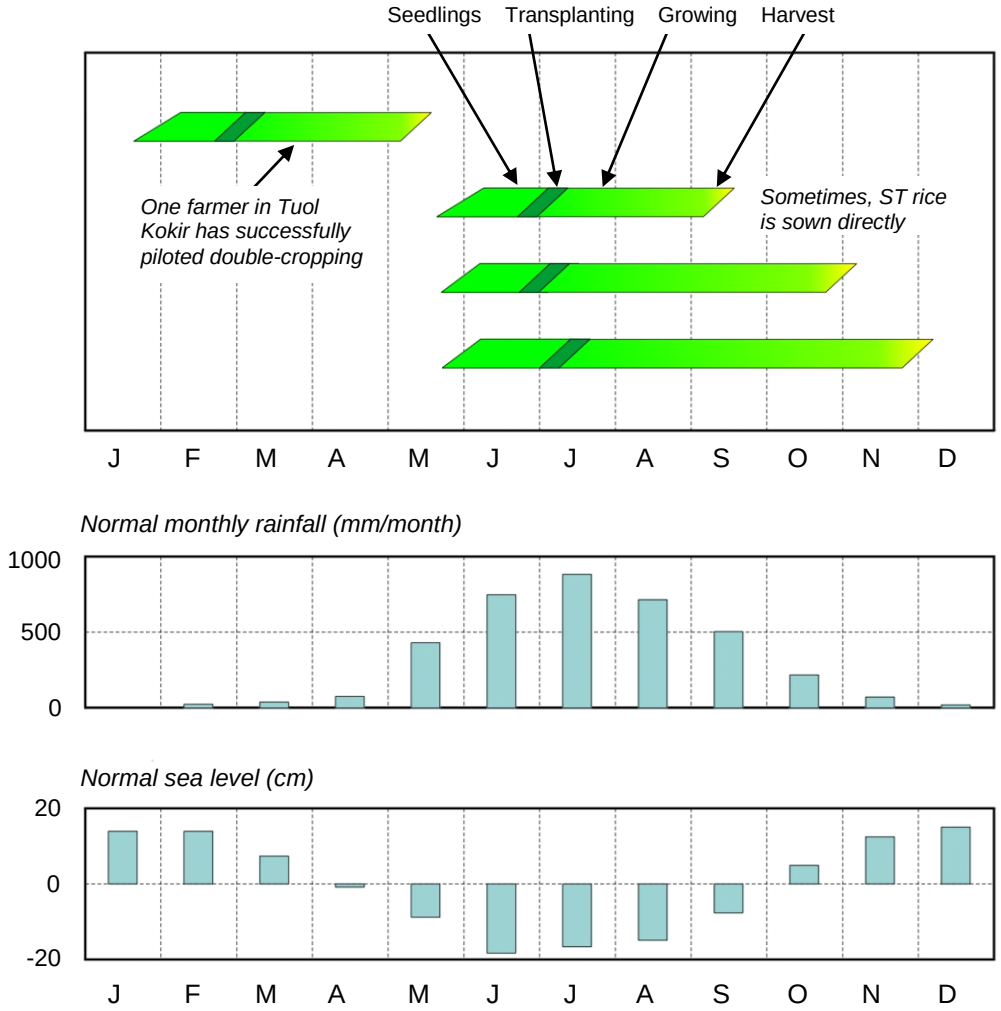
Cultivation

In *Peam Krasaob,* farmers mostly cultivate MT, but ST is becoming more common. The yield is 2 t/ha (one crop per year), achieved without use of fertilizer. Seeds are retained from year to year.

In *Tuol Kokir,* the paddy area is evenly divided between LT and MT varieties. ST rice is being tested (on 2 ha in 2012, sown directly in mid April/late May). More than 10 rice varieties are grown in this commune; but knowledge about the soil quality is inadequate for selecting the best one from case to case.

The cultivation season started early in 2012, due to early rain. The yield is 1.5 t/ha on the average, with one crop per year. Seeds are retained from year t year, except ST, which is bought from relatives in other districts or provinces.

Figure 7: Typical cropping cycles in Peam Krasaob and Tuol Kokir



Fisheries

The majority of villagers in Peam Krasaob are fishing; less are paddy farmers. In Tuol Kokir, villagers are fishing and cultivating. Most fishing is from small boats (that can only operate in fair weather), using traditional (and sustainable) technology. The larger boats that operate in the area are from Thailand. These use modern technology.

The yield is steady, although the number of fishing days is affected by more frequent storms.

In the floating villages, fisheries are the predominant livelihood. The advantage of living in a floating village is that less fuel is needed for the fisheries. Some households have two homes - one floating and one on dry land.

Issues

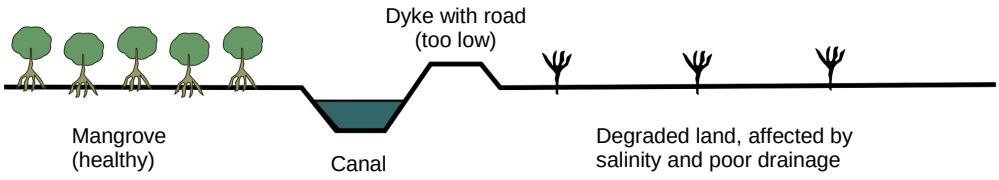
Sea water intrusion is a major concern, seriously affecting cultivation, livestock and household supplies.

Agricultural runoff (polluted by fertilizers and pesticides) can damage the mangroves habitats and ecosystems. This is a potential risk that can be activated in connection with otherwise desirable developments, such as introduction of high-yield rice varieties and crop diversification.

Soil degradation in the areas behind the mangroves appears to be escalating. The degradation is caused by sea water intrusion, probably combined with water logging due to poor drainage. Imperfect operation and maintenance of dykes and gates can be a part of the cause-effect relationships.

Figure 8: Degraded land behind the mangroves in Tuol Kokir

(Photos May 2012)

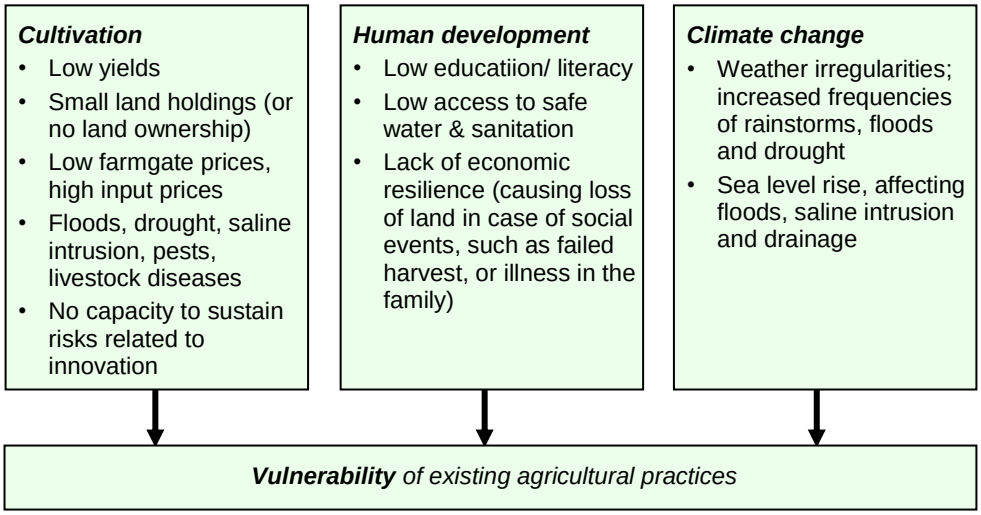


4 Vulnerability assessment

4.1 Context

Most households in the pilot areas have cultivation and/or fisheries as the predominant livelihood. As illustrated below, those households are vulnerable today, and will become even more so under the impact of climate change.

Figure 9: Vulnerability diagramme



4.2 Present and imminent vulnerabilities

Paddy cultivation

Across the present study area, both in Sihanoukville and in Koh Kong, yields are low (2 t/ha or less), and land holdings small (mostly 1 ha per household or less). Apart from various specific threats, the paddy cultivation is adversely affected by low-quality ST and MT seeds, and lack of fertilizer, or less appropriate use of fertilizer.

Cultivation is affected by a number of threats, as illustrated below.

Figure 10: Threats to rice cultivation

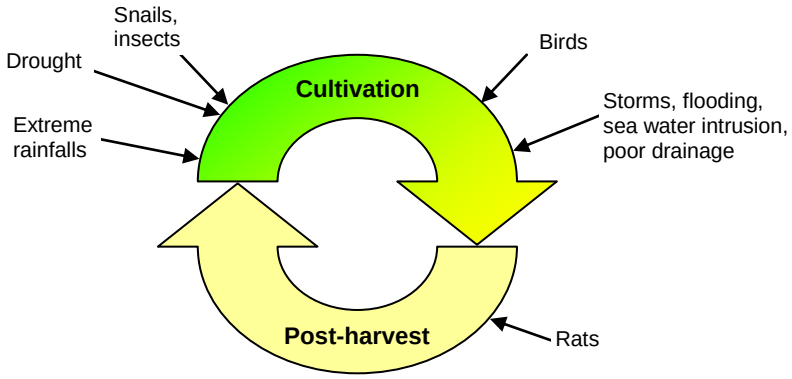


Figure 11: Snails and insects damaging the rice

Photos from Tuol Kokir Commune, May 2012

4.3 The Prey Nob polders

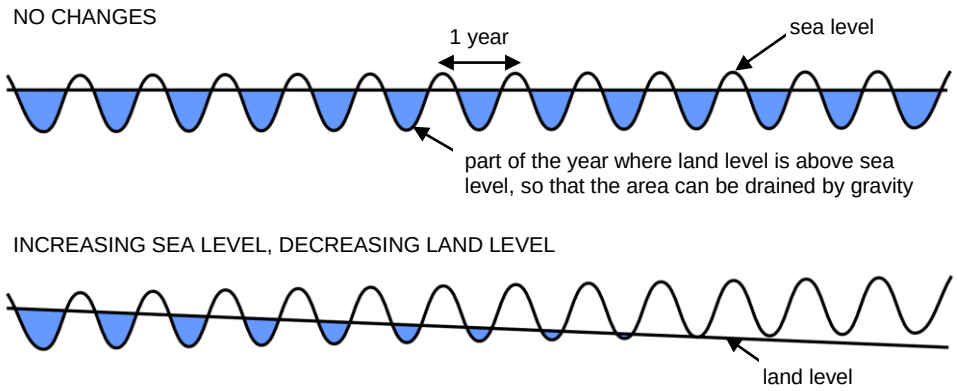
A major concern is the declining margin between the land level (within in the polders, affected by land subsidence) and the sea level (outside the polders, affected by sea level rise). This margin decides to which extent drainage can proceed by gravity flow, as it is the case today.

The monthly average sea level has a seasonal variation with an amplitude of around 30 cm, lowest in June-August and highest in November-February.[7] Today, drainage can take place by gravity flow in part of the time but not all the time, indicating a land elevation within the interval of the sea level variation. As the sea level rises and the land level decreases, this interval will diminish and eventually disappear, as illustrated below.

All evidence indicates that this is going to happen; but it is uncertain how fast.

[7] Data from Koh Chang, Thailand, 1940-2002, available from http://www.psmsl.org/

Figure 12: Long-tem development of land and sea level



Note: This is a qualitative illustration. The time scale is unknown.

At the stage where it is not longer practical that drainage takes place by gravity, there are several options:

- Shifting to salt-resistant production systems: Prawn farming, and/or cattle grazing on salt marshes;
- restoring/heightening the dykes and providing drainage by pumping;
- increasing the land elevation by reclamation (land fill).

All these options are technically feasible. For example, land reclamation for industrial developments has been made and is being planned at many places along the coast. From an economic point of view, however, there is no scope for using the area for paddy cultivation, because the economic benefits would be less than the costs.

5 A look into the future

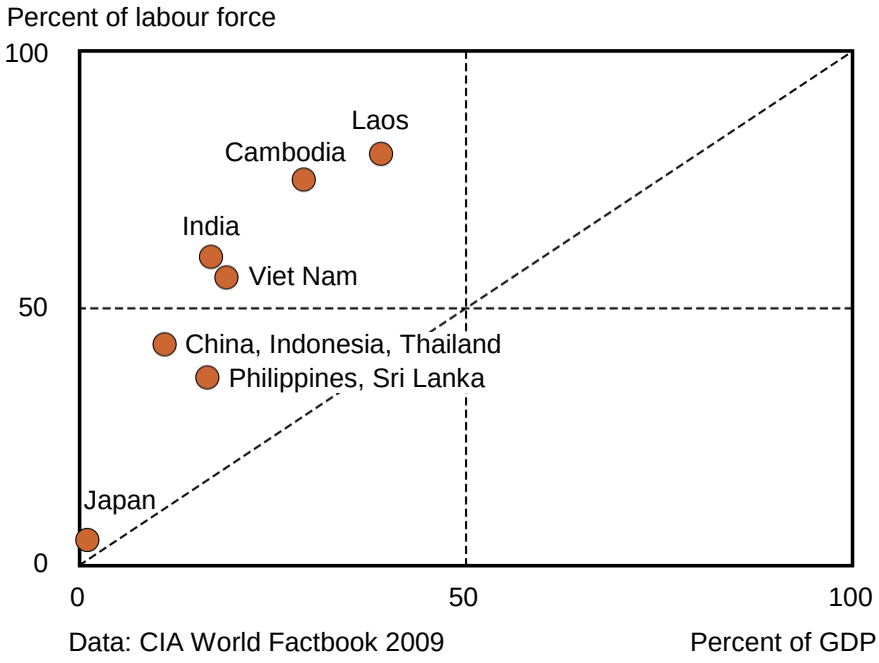
5.1 Paddy cultivation

The context

In her paper *'Paddy cultivation - 20 years from now',* Van Ngo (April 2010)[8] considers the future of the main traditional livelihood. She observes that many countries see their agricultural sectors lagging behind industries and services in terms of technology and revenue.

This is illustrated by the figure below, which shows examples of employment in agriculture being much higher than the sector's contribution to the national economy.

Figure 13: The agricultural sector's contribution to GDP and employment



This means that there is less revenue to share than it is the case within industry and the service sector.

Of course there is no rule saying that each sector should generate an equal value - in terms of money - per employee. (Rather, in an economic perspective, the sectors should contribute to the best of their potential, and in a social perspective, food is important in its own right). On the other hand, the imbalance seems consistent with the fact that paddy cultivation can be a hard way to earn a living.

In a strongly generalised way, a simple distinction can be made between three stages of the paddy cultivation sector, as described below.

Today

Traditional production units are household-based and small. Some household members may seek a living off the farm, and bring back cash. A few cows and buffaloes can

[8] The entire chapter is based on this paper

make a visible difference to the household economy, and so can a bit of seasonal fishing.

Paddy cultivation is labour intensive, but typically the peak demands of labour, for transplanting and harvesting, are extreme, short and synchronised. If the cultivation is rainfed, without reliable access to irrigation water, it becomes vulnerable to weather irregularities. In some places, the yield is low (but the quality can be high). Access to markets can be impeded by a variety of physical and structural (market-related) constraints.

Irrigated paddy cultivation is (and will remain) the predominant off-stream water use.

A transition process

The process of structural change is important, because it will affect many households over a time span of decades.

The agricultural sector will diversify, and the thrust of its development may occur for production systems other than rice. Food production will increase, but the process will see a big loss of employment in traditional paddy cultivation.

The production unit - the farm size - will increase, driven by new technology that requires less labour but more capital, combined with a need of higher production efficiencies - more output and higher value per unit of input. Labour-intensive production systems - such as the System of Rice Intensification (SRI) - will be marginal.

The changes are driven by a combination of circumstances. Lower trade barriers will increase the exposure to competitive pressure, reflecting comparative advantages and disadvantages, as well as exposure to global price fluctuations - a tendency that will interact, in an unpredictable way, with escalating weather irregularities caused by a global climate change. New lifestyles will affect the demand of many commodities, including food (and energy) - for example if people consume more meat. A new demand of biofuel is a distinct possibility. The recent tendency of large-scale international acquisition of agricultural land (and water) will affect the availability of production factors and have an explicit purpose of increasing the supply of food and other agricultural products - although perhaps in distant countries.

The use of pesticides (and fertilisers) will escalate, partly necessitated by the diversification. Pesticides can end up in the environment and can contaminate edible fish and water used for drinking.

Higher revenue per ha will make agricultural lands an investment object - a bit like it occurred during the green revolution, and as it is clearly seen when an area is supplied with irrigation infrastructure. Small-scale land owners risk losing their land in connection with irregular weather or in case of social shocks, such as illness in the family.

The future

Rice will remain the favoured staple food. Revenues of the agricultural sector will increase, but a large part of the value will be generated by crops other than rice, as well as meat, and, quite likely, biofuel.

Less labour-intensive production systems will prevail. The technological development will proceed in the direction of further diversification and continued efficiency improvements, covering primary production, livestock and processing.

Lower trade barriers will increase the exposure to price fluctuations. Also, there will be a much higher exposure to competition, which will benefit the more efficient production systems at the cost of less efficient ones.

Policy implications

Between them, the various challenges clearly indicate a need of change. Below are listed some policy implications, in random order.

- ***Efficiency improvement*** is a general aim, considering the need to improve the income of the farmers, in an increasingly competitive environment, while, at the same time, producing more food with less water. This comprises the water efficiency - ton per m3 of water output - as well as the economic efficiency - value generated per m3 of water.
- Another important aim is ***livelihood generation,*** expectedly mainly outside the farms, but preferably including rural livelihoods, in order to reduce the rate of (an unavoidable and possibly eventually beneficial) urban migration. Towns must grow, and will, but best at a rate that allows for facilities, infrastructure and services to grow accordingly.
- A ***value chain perspective*** can support generation of revenue and livelihoods, for example by encouragement of agro-processing, including innovative products, and partly undertaken de-centrally by small and medium enterprises.
- ***Branding*** of products and related marketing can, sometimes, add attractive value at a moderate cost.
- Gentle, pro-poor ***market regulation*** can be applied in support of shifting to new products (perhaps biofuel), and in support of a common national aim of affordable food prices while at the same time maintaining an income of the farmers that at least exceeds their production cost. A high predictability will support the intended outcome and reduce the risk of adverse effects.
- ***Credit,*** including (but not limited to) micro-credit, is a general precondition for investment and innovation. Some kind of ***risk insurance*** can make it possible for the farmers to keep their land in case of emergencies.
- ***Water uses must be regulated.*** There is a particular scope for strict regulation of new, water-dependent industries, because these can adapt more easily than existing ones with older technology - and sometimes even saving water, energy and money at the same time. The regulation must cover both surface water and groundwater.
- ***Disaster preparedness*** (for floods, drought and pests) must be in place.
- ***Organisation of farmers*** (like in water user groups) can facilitate efficiency improvements, other kinds of technological development, and access to markets.
- ***Soil management*** will become more important (and the benefits more visible) when water is sparse and in connection with diversifying the cultivation on lands that are not well suited crops other than rice.
- ***Use of pesticides*** must be kept at acceptable levels, supported by education and awareness campaigns and supportive extension and weather forecast services.
- ***Continued research*** is required, including international networking, knowledge-sharing and active collaboration. Results must be made available to the end

users by pilot and demonstration activities, well functional extension services, and networking among farmers - possibly across borders.

Agricultural development must be cautious and gradual. There is always a risk of unforeseen adverse side effects when implementing new technologies, and even when implementing existing and well proven technologies in new places. If everyone grew water melons the market would fail.

5.2 The future of the Prey Nob polders

The sustainable development of this area is a particular challenge. Some aspects are summarised in the table below.

Table 3: Development characteristics of the Pry Nob polders

Strengths	Residents/land owners well organised Good management by the FWUC Low drought exposure as compared with inland areas (adding to the food security value of the area)
Weaknesses	Low yields Small land holdings Low elevation (close to mean sea level), impeding drainage Inadequate height of outer dyke
Opportunities	Potential for salt-resilient (low-medium value) production systems; and for land use for (high-value) purposes other than cultivation Good location (next to National Road 4)
Threats	(1) Sea level rise; and (2) continued land subsidence; adding to the flood risk and salt water intrusion; and quite likely preventing drainage by gravity flow in the course of time Increased weather irregulatities, higher storm exposure, perhaps drought incidents Risk of land degradation due to water logging

6 Socio-economic and environmental implications

6.1 Challenges and opportunities

General

General climate-related threats in the study area include [9]

- coastal erosion, accelerated by storms and sea level rise;
- loss of livelihoods (within agriculture, fisheries and tourism);
- deterioration of mangroves and coral reefs; and
- risks to human health.

Access to *safe water and sanitation* is an important general concern.

Paddy cultivation

One viable (and broadly acknowledged) strategy is a shift from (traditional) long-term varieties of rice to (new) *medium- and short-term varieties.* In the coastal areas, this will reduce the risk of exposure to seasonal sea water intrusion, storm surges and strong winds. In inland areas, where drought is a major concern, short-term varieties can be more resilient to seasonal water shortages. National expertise is available, and a range of locally tested varieties; but proper implementation depends on the site-specific context and requires knowledge about the local weather conditions. In some parts of the country, such information is provided by a network of agricultural experiment stations; but the network is patchy (and does not cover the areas of the present study).

Drought is not a problem in the study area (although there is some evidence of drought incidents in Tuek L'ak early in the cultivation cycle). CC is expected to cause increased weather irregularities, which may well include more frequent dry spells early in rainy season (as it is the case elsewhere in Cambodia).[10] If so, this area could be particularly vulnerable, because farmers (and authorities) are unfamiliar with this challenge. Experience is available from inland provinces and might be shared with the coastal area.

Livestock

Livestock must not be overlooked as a supplementary source of income, and, not least (in the case of buffaloes and cows) as a financial reserve for households that are otherwise vulnerable in this respect.

There are visible differences within the study area regarding the state of the livestock, even within short distances, mostly (apparently) due to different breeds.

For all kinds of livestock, expenses for fodder are regarded as high as compared with the potential income. This is also the case for fish farming. Profits are *'paper-thin'* or non-existent.

Vaccinations are piloted in some areas, while elsewhere, farmers are sceptical.

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[9] According to mr. Prak Visal, ICM-Coordinator, SHV Municipality (June 2012)

[10] By early July 2012, drought had damaged over 20,000 ha of rice fields in Battambang, Preah Vihear, Pursat and Kg Speu

6.2 Suggestions on demonstration activities

Appropriate demonstration activities are characterized by

- support from intended beneficiaries and involved agencies;
- clear social, environmental, and/or economic benefits achieved within a reasonable time scale - notably including livelihoods;
- low risks in general, and to involved households in particular; and
- realistic resource requirements, including capacity of implementing institutions and partners.

Some candidate activities have been identified for further consideration, as outlined below. [11]

General

Support to formation/consolidation of ***farmer and fishery communities*** (for networking and learning from each other; information about production and damage control technologies; marketing of niche products; resource conservation; and perhaps savings/microcredit/insurance)[12]. These could be thematic, rather than geographically delineated.

Support directly to ***farmer households,*** covering for example use of high-quality seeds (including short-term varieties); use of inorganic fertilizer; pest control; livestock breeding and livestock vaccination; and small-scale supplementary dry season cultivation.

Ou Oknha Heng, Prey Nob and Tuol Totueng Communes, Preah Sihanouk

A ***tree-planting scheme,*** to break the wind, using well suited species that can provide additional benefits. Possibilities include *sang kae tree* and *rang boeng tree,* both of which occur locally. Another candidate is *teap tues tree*[13]*.* With suitable documentation, such a demonstration activity could provide a useful example for replication elsewhere.

Figure 14: Fruit of teap tues tree (edible)

11 Suggestions on capacity-building are made in a separate working paper

12 There is one (successful) savings/microcredit group in Peam Krasaob)

13 Recommended by Yim Boy, chief of the Prey Nob FWUC

Compartmentalization of the polders (to confine exposure to sea water intrusion). One concern in this connection is the drainage implications; the feasibility needs to be further considered.

Systematic ***monitoring of salinity and land subsidence.***

Sameakki, Tuek L'ak and Tuek Thla Communes, Preah Sihanouk

Support to ***appropriate use of fertilizer and pesticides.***

Promotion of ***better seeds,*** particularly high-yield ST varieties.

Support to ***supplementary livelihoods,*** including small-scale supplementary crops and livestock. This could involve networking among farmers within and outside the area, to learn from each other.

Peam Krasaob and Tuol Kokir Communes, Koh Kong

The Tuol Kokir area reaches across high and low exposure to sea water intrusion, and yields vary accordingly, from around 1 to around 3 t/ha/year. The farmers are innovative (more than 10 seed varieties are used) and the DoA is active in providing guidance regarding rice varieties and various cultivation and damage control techniques. The area could serve as ***a 'controlled laboratory' for identification of appropriate seeds and cultivation practices***, testing various options side by side, and with appropriate environmental documentation (rainfall, sunlight radiation, sea water exposure, adverse weather events, pest attacks, etc). Appropriate use of inorganic fertilizers could be included. The participating farmers should be secured against economic risks. Such an activity could provide highly useful knowledge to other coastal areas within and outside Cambodia, provided that results are duly disseminated.

Support to dissemination and promotion of recent, apparently positive experience with ***two crops per year,*** using appropriate seeds and cultivation techniques. 2 ha was cultivated last year, with seeds from CARDI, and the area is being expanded this year[14].

Support to appropriate ***land use and soil management*** in areas next to the mangroves (part of which are in a state of rapid deterioration).

Support to community-based ***zoning of fishing areas*** (as suggested during consultations with district and commune representatives in May 2012). Efforts have been supported for a decade under CBNRM and IDRC, but the need seems to remain.

6.3 Bottom line

Many of today's agricultural practices in the study area are utterly unsustainable. Even with a much higher rice yield, and much better farmgate prices, many households will remain locked in poverty if they rely on existing cultivation as a main livelihood.

The transition between today and the future is a major challenge. If conducted smoothly, the sector will emerge as prosperous and competitive, well placed to generate income for the farmers and food for the population. If conducted less smoothly, there is a risk of unemployment, and farm incomes that are even lower than today. This can happen if the changes take place too fast, or without appropriate support.

[14] Information from DOA, KK (June 2012)

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