# Documentation of Selected Adaptation Strategies to Climate Change in Rice Cultivation

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# EXECUTIVE SUMMARY

This paper highlights published cases related to various climatic conditions that have impacts on rice cultivation practices. Due to the needs to continue rice farming, whether for traditional, cultural or economic reasons, rice farmers in Asia resorted to various adaptation practices that might have deviated from their common practices. This includes the introduction of modern technologies or new rice varieties that promised to withstand the effects of adverse climatic conditions.

There are various climate changes that are commonly addressed. These include heavy monsoon rains, droughts, forest fire, rising sea level, temperature increase, intense rainfall, typhoons, frequent of extreme weather variability, floods, high salinity, warmer winter and cooler summers, reduced precipitation, prolong cold spell, inappropriate rain, soil erosion and dry spell. This research studied the impacts of droughts, floods, and cold spells on rice production in Thailand, Vietnam and the Philippines.

Various adaptation strategies were adopted by farmers to address the effects of climate change. These strategies were undertaken, either voluntarily or by accepting recommendations given by agricultural experts and institutions that ostensibly will lead to better rice production or discontinue rice farming and shift to other economic activities.

# INTRODUCTION

Asian farmers account for about 92 percent of the world's total rice production. More than 550 million tons of rice is produced annually around the globe, mainly from India, China, Japan, Indonesia, Thailand, Burma, and Bangladesh.[1] Ninety per cent of rice in Asia is produced by small farmers who depends on rice farming for their livelihood and food security (ANU, 2006).

The climate change (CC) indicators that are commonly associated with rice production are examined, and their biophysical impacts on agricultural environments and crops, particularly rice have been identified as:

- physiological effects on rice crops, fields, surroundiing forests and livestock
- changes in land, soil and water resources
- increased weed and pest challenges;
- sea level rise
- increase in temperature
- increase in $CO_2$
- erratic weather conditions

***Vietnam exports nearly 4.5 million tons of rice annually. Vietnam, the second largest rice exporter, is also a major supplier of rice for the World Food Program.***

***Thailand is the largest rice exporter and exports 9.5 million tons annually.***

***Approximately 30 million tons of rice was supplied to the global market in 2007.***

***(Macan-Markar, 2008)***

Climatic variability, such as abnormal changes in air temperature and rainfall, resulting in erratic patterns, frequency and intensity of drought and flood presents long-term implications for the viability of the rice farming ecosystems. As climatic patterns change, so as the spatial distribution of agro-ecological zones, habitats, distribution patterns of plant diseases and pests, biodiversity and water availability patterns, which can have significant impacts on rice and other crop production for the farming communities.

The secondary level of the CC impacts spilt over onto the socio-economic circumstances following the manifestations of the CC and its biophysical impacts on the rice farming communities. These socio-economic impacts could be indicated by:

[1] Rice Trade (2008)

- decline in yields and production;
- reduced marginal GDP from agriculture;
- fluctuations in world market prices;
- changes in geographical distribution of trade regimes;
- increased number of people at risk of hunger and food insecurity;
- migration and civil unrest.

Based on the general descriptions of CC related indicators, this research intended to document relevant physiological and environmental indicators that have been reported to have direct impacts on rice cultivation practices and production. The CC indicators include:

- enhanced $CO_2$ on crop growth
- higher temperature
- Water availability
- Climate variability (extremities) - intense drought, cyclones, typhoon, heat waves
- Soil fertility and erosion
- Pests and diseases
- Sea-level rise
- Soil or water salinity

# OBJECTIVES AND METHODOLOGY

## Research Objectives

This research aims to provide a reference towards understanding the impacts of climate change on rice production. It also intends to provide information on strategies or methods that were adopted in handling or overcoming the effects of adverse climatic conditions.

It is intended that this document will be of use to civil society groups or farmers' groups in Southeast Asia.

The cases that were studied represent different climatic conditions. Different strategies adopted for handling a similar climatic condition experienced by different communities in different regions are also compared. Different communities in different areas or provinces may be confronted with similar or different climatic factors but they have their ways of adapting.

## Methodology

This research mainly used document review. The information, data and cases presented has been collected and compiled from the internet and published materials.

## Limitation of the study

The cases documented in this report might have limited details due to the unavailability of information, particularly with regard to adaptation strategies for rice cultivation. Limited facilities or resources have also prevented in accessing necessary information which required access fees. Various published cases were encountered through the research, but selections for this report were confined to cases in the Philippines, Thailand, China, Vietnam, Cambodia and Indonesia as they were found to have more necessary and in-depth details for the purpose of this documentation.

# CLIMATIC CONDITIONS FOR RICE CULTIVATION

Different varieties of rice cultivated respond differently to climatic factors. However, there are a number of climatic conditions that are essentially crucial for optimum growth of rice plants or paddy.

> ***IRRI reported that average daytime temperatures increased by 0.35°C since 1979.***
>
> ***The yield of rice was reported to strongly correlate to night-time temperatures. The increase of night-time temperatures around 1.1°C over a quarter century was correlated to the declining yields.***
>
> ***IRRI experiments indicated that a one-degree increase in***

## Rainfall

Rainfall is the most important weather factor for successful rice cultivation. Understandably, the distribution of rainfall is greatly influenced by the physical features of the terrain, the situation of the mountains or plateau, as well as the geographical locations on the globe.

## Temperature

Rice is a tropical and sub-tropical plant. As such, temperature is another climatic factor that significantly influences the development, growth and yield of rice. Rice requires a fairly high temperature between 20°C and 40°C.[2] The optimum temperature of 30°C during day time and 20°C during night time seems to be more favorable for the development and growth of rice crop.

## Day length or Sunshine

Sunlight is important for the development and growth of the plants. Sunlight is the source of energy for plant life. The yield of rice is influenced by the solar radiation particularly during the last 35 to 45 days of its ripening period. The effect of solar radiation is more profound where water, temperature and nitrogenous nutrients are not limiting factors. Bright sunshine with low temperature during ripening period of the crop helps in the development of carbohydrates in the grains.

Some of the common issues on rice cultivation:

- About 90% of the farmers in Asia are small, marginal and are poor in resource.

2. Rice Trade, as accessed in August 2008.

- In many parts of Southeast Asia, use of hybrid rice varieties has increased in attempt to adapt to climate change, which eventually could lead to loss of traditional varieties, hence agro-biodiversity.
- Poor soil and environmental management have resulted in cases of soil erosion, loss of plant nutrients and moisture.
- Increased use of chemical fertilizers and pesticides coupled with low environmental management contribute to climate change and socio-economic vulnerability.

***The average seasonal consumptive use of water for rice cultivation is 795 mm, where 72% of this amount is used for evapotranspiration and 28% for percolation.***

- Heavy infestation of weeds, insects or pests is still common in rice fields.
- Unpredictable monsoon onset often results in delayed and prolonged transplanting season, particularly in rain-fed lowlands.

# ADAPTATION STRATEGIES TO CLIMATE CHANGE IN RELATION TO RICE FARMING

This research explored two types of adaptation strategies:

- Autonomous Adaptation
- Planned Adaptation

Autonomous Adaptation (AA) refers to the reaction of farmers to address problems at farm level. This strategy is based on the farmers' own initiatives and creativity to overcome a climatic-related problem in their rice farming activities, whether they consciously or unconsciously able to relate the cause to climate change. Autonomous Adaptation strategy also reflects on the experience and knowledge (traditional or cultural) of farmers in rice farming. These strategies include changing crops or using different harvest and planting/sowing dates, or digging ponds to store rain water in their fields.

Another form of adaptation strategies is categorized as Planned Adaptation (PA), which refers to a conscious policy option or response strategies that are commonly introduced to the farmers by authoritative figures, including government and research institutions. This adaptation is often multi-faceted in nature, aimed at altering the adaptive capacity of the agricultural system or facilitating specific adaptations, including deliberate crops selection, extensive irrigation project, and new policies that affect farming practices. This adaptation could present long-term impacts as major structural changes take place to overcome adversity such as changes in rice variety to maximize yield under new conditions; application of new technologies; new land management techniques; and water-use efficiency related techniques.

### Examples of adaptation strategies in rice cultivation and production

- Investments in water storage
- Development of drought-tolerant crops
- Crop diversification for those farmers at greatest risk
- Water-saving technologies such as alternate wetting and drying irrigation and aerobic rice (a production system in which specially developed, high yielding varieties are grown in well-drained, non-puddle, and non-saturated soils).
- Molecular marker techniques to speed up the cultivation process;
- Geographic analysis of vulnerable

regions (where the rice crop is already experiencing critical temperature levels);

- Regional climate modelling to identify future "tilting points" of rice production (temperatures or $CO_2$ levels above which major yield losses are experienced, for example);
- Site-specific adjustment in crop management (shifting planting dates and improved water management, for example)
- Governments' plans and interventions in anticipation of weather-related calamities such as El Niño.

### Possible Adaptation Strategies to Climate Change in Rice Farming

- Change varieties
- Change cultivation area
- Diversify
- Crop rotation
- Systemize irrigation
- Drainage
- Tillering
- Aerobic cultivation
- Rice intensification (SRI)
- Equipment
- Farming techniques
- Mechanization
- Inputs (fertilizers, pesticides)
- Alternate wet and dry system
- Farm animals
- Change planting and harvesting dates (crop management)
- Tree planting (buffer zone, rooting)
- forest fire management, promotion of agro-forestry, adaptive management with suitable species and civil-cultural practices

### Common Indicators Associated with Climate Change and Rice Production

- enhanced $CO_2$
- higher temperature
- Water availability
- Climate variability (extremities) - intense drought, cyclones, typhoon, heat waves
- Soil fertility and erosion
- Pests and diseases
- Sea-level rise
- Soil or water salinity

### Socio-economic Indicators that are Co-related to Climate Change

- decline in yields and production;
- reduced marginal GDP from agriculture;
- fluctuations in world market prices;
- changes in geographical distribution of trade regimes;
- increased number of people at risk of hunger and food insecurity

# Case 1
## PROLONGED COLD SPELL
## Location: Northern Vietnam[3]

A cold spell is defined as consecutive days with temperatures below 0°C.[4]

A month-long cold spell that occurred in December 2007 to January 2008 was reported in Northern Vietnam, with the temperatures kept declining to less than 13°C.

The cold spell was reported to have destroyed at least 53,000 hectares of rice, mainly the winter-spring rice acreage.[5] Haiphong, Hai Duong and Thai Binh reported 25,000 hectares of rice affected. Damaged crops in Nghe An and Thanh Hoa provinces total about 20,000 hectares. The upland provinces of Bac Kan, Lang Son and Son La were badly hit by frost as temperatures dropped to 0°C or lower.

> ***Optimal temperature for rice:***
>
> ***Day temperatures of 28-32°C are standard, with night temperatures about 3°C lower.***
>
> ***(Cornell, 2004)***

Reported figures showed that at least 5,000 hectares of seeds in 16 northern provinces in Vietnam were devastated due to the climatic condition.

### The consequences

Many farmers suffered lost of livelihood. Along with rice farming, other agricultural activities including husbandry, were also badly affected. Agricultural engineers had to get involved to supply farmers with techniques to protect the areas under newly-sown rice seeds.

### Adaptation Measures

Rice farmers were warned by government officials against sowing rice seeds when temperatures are down to less than 15°C.

Rice farmers were further advised to find effective methods to protect their seeds.

In response to this situation, the Vietnamese Ministry of Agriculture and Rural Development called upon private enterprises to import more rice seeds to offset the shortage caused by cold weather. Farmers were provided with enough rice seeds, a reported amount of 35,000 tons of rice seeds to replace their crops. Budgets for seeds were drawn from both central and provincial government budgets in order to supply district authorities with seeds.

Farmers were also introduced to a new line of rice seeds, the P6 rice seeds, which was said to have the capacity to survive even the cold and have high productivity. From 2001 to 2004, P6 seeds were tested for resistance against major

3. Nhan Dan Business, March 21, 2008
4. Holt and Palutikof (2004)
5. February 15, 2008 by tinquehuong

diseases and pests under artificial conditions and were found to be lightly resistant to rice blast. The seeds, however, are susceptible to bacterial blight.[6]

Additionally, farmers who were indebted to the government also had their loans frozen and qualified for an emergency loan to resume work.

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## Case 2

## UNPREDICTABLE FLOODS/INUNDATIONS, ERRATIC RAINS, AND DROUGHTS

## Locations: Long An, Can Tho, Dong Thap, An Giang / Vietnam[7]

The four provinces of Long An, Can Tho, Dong Thap, and An Giang are located in the Mekong River Delta (MRD) in Vietnam. Rice production is a major agricultural activity in the area with a production capacity of more than 1 million ton of rice per year. Unfortunately, the rice farming communities in these areas have been exposed to a mixture of adverse climatic conditions:

- Drought during winter-spring cropping season.
- Dry spells in rainy season
- Prolonged rainfalls
- intense sun in dry season that leads to drought
- Long lasting flood
- Extended flooding areas
- Deep inundations

Climate risk analysis conducted by Chinvanno *et al* (2007) showed that 27% of the households were highly vulnerable, 53% were moderately vulnerable, and 20% were least vulnerable to the impact of climate change. The vulnerability factors were determined by various indicators including household economic status, rice production dependency and coping capacity.

### Adaptation Strategies

Given the mixed climatic conditions and the different degrees of vulnerabilities that the rice farming communities were exposed to, different coping strategies were adopted to overcome the impacts.

> ***Scientists at the International Rice Research Institute believe that sub1 gene, as carried by "Swarna submergence", allows rice to essentially "hold its breath" for up to two weeks.***
>
> ***(Hamilton, 2008)***

Tables 1(a), (b) and (c) present the various coping-strategies adopted by farmers. The economic capacities of the household or the community are very much relevant in determining the kind of strategies adopted. The least vulnerable group, for example, was

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6. VISTA, 2005.
7. Chinvanno *et al*, AIACC AS 2007

able to buy a drying machine and continue agricultural activities during long rainy period, compared to the highly risky group that would not be able to carry on with their agricultural related activities.

One of the strategies recommended to the farmers was an exposure to a new rice line known as variety "Swarna submergence." This new flood-tolerant rice carries sub1a gene that enables the rice plant to withstand submersion in water for up to 17 days. The newly developed rice is still under field trials and is promised to be made available to farmers by 2009.8

The announcement of flood-resistant rice as "Offers Relief for World's Poorest Farmers" was made during the 3rd steering committee meeting of the Irrigated Rice Research Consortium of the International Rice Research Institute (IRRI) in Hanoi, Vietnam 8-9 October, 2007.

**Table 1 Coping strategies adopted by the moderate vulnerable group faced by climate change related situations in Vietnam.**

(a) Low risk group

| | **Experience in coping with climate change to reduce adverse impacts** | | | | |
|---|---|---|---|---|---|
| | ***Normally flooded*** | ***Deeply flooded*** | ***Long-lasting flood*** | ***Drought for long time*** | ***Rain for long time*** |
| Low vulnerable group<br>13 House-holds | pumping, embankment, drainage | | | pumping, drainage canals, dredging,, | |
| | | fish breeding | | buy drying machine | |
| | short term rice, appropriate crop | | earlier harvest | | |
| | | | out of control | | |

Adopted from Chinvanno *et al* (2007)

(b) Medium risk group

| | Experience in coping with climate change to reduce adverse impacts | | | | |
|---|---|---|---|---|---|
| | ***Normally flooded*** | ***Deeply flooded*** | ***Long-lasting flood*** | ***Drought for long time*** | ***Rain for long time*** |
| Moderate vulnerable group<br><br>34 households | pumping, embankment, drainage | | | pumping, drainage canals, dredging,, | |
| | short term rice, appropriate crop | 2 crops, appropriate crop and breed | | other crops, drought resistant varieties | more solid stem breed |
| | | | machinery intervention | fertilize | buy drying machine |
| | | earlier sowing | earlier harvest | | |
| | | | no crops, unable to cope | | |

Adopted from Chinvanno *et al*(2007)

(c) High risk group

| | Experience in coping with climate change to reduce adverse impacts | | | | |
|---|---|---|---|---|---|
| | ***Normally flooded*** | ***Deeply flooded*** | ***Long-lasting flood*** | ***Drought for long time*** | ***Rain for long time*** |
| Moderate vulnerable group<br><br>34 households | pumping, embankment, drainage | | | irrigation, drainage, canal and river dredging embankment; strengthening canal system | |
| | reducing water | reduce no. of crops/yr., change sowing time | earlier harvest, later sowing | | |
| | short-term rice, appropriate crop, appropriate production zones | | short-term rice | drought resistant varieties | buy drying machine |
| | unable coping | live with flood | | | |

Adopted from Chinvanno *et al*(2007)

# Case 3

## UNPREDICTABLE FLOODS, DROUGHTS AND SOIL EROSION
## Location: Lovethom, Cambodia[9]

Lovethom, a small village in Cambodia's northern province of Kratie, benefited from living on the fertile Mekong river flood plains. The seasonal flooding each year provides fish and just enough water for rice cultivation. In the last three years, the village has experienced unpredictable floods (Oxfam America, 2007).

The flood plain normally overflows from July until September. Then the water starts to recede when rice planting starts. However, in the past three years, heavy rains had changed the patterns of water retention failing to recede by September. This consequently led to an increase water level in the field as the cycle of rains started again, destroying everything in its path.

> ***30 November 2007***
>
> ***Unpredictable floods destroyed the rice crops of the Cham people, forcing families to migrate in a search for survival.***

### Socio-economic impact

Most farmers in the village tilled small plots of land that are barely enough even to provide for family's consumption. The continuous three-year destructions due to flooding have left farmers with limited revenues and capital to proceed with their farming activities. Ultimately, many of them had no means to buy seeds or other agricultural inputs to plant for the following.

### Adaptation Strategies

In order to survive the impact of the adverse climate condition, the rice farmers made necessary adjustments by:

- shifting planting date. Specifically, rice seedlings are planted in November (the last month of the wet season) after flood water recedes, instead of in September.
- diversifying jobs: pressing palm leaves to sell as thatch walls and roofs as well as selling porridge and banana leaves.
- integrating other farming activities such as cattle raising and vegetable planting
- improving irrigation systems

> ***Research conducted by the Climate Change Office of the Cambodian Ministry of Environment has proven that agricultural productivity has gone down during the past five years because of increased flooding, drought and sea water intrusions***
>
> ***(Oxfam America, 2007)***

The severity of the socio-economic impact of the floods had forced many family members to leave the community in search of work in other areas or country. Some went to as far as Thailand to work as laborers. Some

9. Oxfam America 2007

found work on a bean plantation in the northern region, or press palm leaves to sell as thatch walls and roofs, or sell porridge and banana leaves, or sell firewood collected from surrounding forest.

This migration had consequently caused a severe lack of manpower to work on the farm in the village.

> At the eighth Conference of the Parties to the United Nations framework Convention on Climate Change (UNFCCC), least developed countries including Cambodia was identified as most vulnerable to climate change. Fund allocation could be applied for through submission of National Adaptation Plans by relevant countries (Oxfam America, 2007).
>
> Cambodia identified 39 projects under its National Adaptation Program of Action to Climate Change (NAPA) encompassing water resources, agriculture, human health and coastal zone management, through various projects including integrated farming such as cattle raising and vegetable planting. This would help to reduce dependency on rice farming as the main source of income
>
> *(Oxfam America, 2007)*

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## Case 4

## PROLONGED DRY SPELL, DROUGHT HIT IN JULY 2007

## Locations: Central Luzon, Cagayan Valley, and Ilocos Region, Philippines[10]

The Philippine climate is generally characterized by four climatic types in terms of the relative duration and intensity of the wet and dry periods in different parts of the country (Lansigan, 2003).

- *Type 1 climate*
  Wet period from May to November, and a dry period from December to April.
- *Type 2 climate*
  No clear dry season, and maximum rainfall is experienced from November to January.
- *Type 3 climate*
  No distinct wet and dry seasons but is relatively dry from November to April.
- *Type 4 climate*
  Presence of rainfall more or less evenly distributed throughout the year

Ilocos Norte was one of the provinces worst hit by droughts experienced

10. Rice Today. Mar 2008. IRRI

from June 2007 to August 2007 in Northern Luzon along with Ilocos Sur, La Union and Pangasinan. Before the dry spell hit, Ilocos Norte had high sufficiency level in the rice (280%), corn (1,642%), garlic (2,734%) and onion (11,036%).

Autonomous Adaptation Strategies adopted by the rice farming community included:

- **Delaying rice planting** for four months, as rice seedlings were short and small due to lack of water
- **Alternative crops:** Planting maize, vegetables, and other dry-season crops instead of rice in late August

As a pro-active measure, the passage of the bill declaring the Province of Ilocos Norte under a state of calamity due to the prolonged dry spell was made by the governor.[11] Planned adaptation strategies with the aid from Department of Agriculture included the following:

**a) Cloud-seeding**

Cloud seeding is a form of weather modification, commonly used to increase precipitation to induce rain, disperse fog, suppress hail, or control winds. In warm temperatures, cloud droplets are formed around particles of dust, salt, or soil *(cloud condensation nuclei)* often present in the atmosphere. These cloud droplets formed from cool and condensed air made of tiny droplets of water, merge with other droplets. The merging becomes heavy and fall to the Earth as rain. It takes millions of cloud droplets to form a single raindrop (Malkus and Simpson, 1964).

In the case study, cloud-seeding was carried out in farmlands where irrigation was needed most.

**b) Shallow tube wells, or water-impounding projects**

Low cost, hand-drilled shallow tube-wells for irrigation have become very popular in many parts of the world. Traditionally, farmers lift water from shallow dug-outs and dug-wells for individually-managed micro scale irrigation in the dry season. Discharge is low and can only allow small irrigated areas.[12] The provincial government of the affected areas in the Philippines was also called to provide water pumps. Additionally, the government extended assistance in providing fuel for the operation of those pumps.

***Rice plants require between 450 and 700 mm depending on climate and length of growing period, for evapotranspiration, compared to cotton (700-1300mm), sugar cane (1500-2500 mm) and maize (500-850 mm).***

***(Doorenbos and Kassam, 1979).***

IRRI

11. Ilocos Times News Updates
12. M. Sonou, FAO 1997

The irrigation systems in the province were expected to require more than PhP318 million for rehabilitation in order to reach their highest level of efficiency. Most of the dams in the province had suffered some damages due to successive typhoons since 2006.

**c) Identify alternative crops that are drought-resistant**

The provincial government was also advised to promote the planting of more high-value crops and vegetables and identify alternative crops that are drought-resistant. PhP30 million were allocated for the purpose including the funds for farm-to-market roads and improving irrigation infrastructure. The mitigating efforts called for cooperation across government officials and mayors to include the provision of seeds for alternative non-water intensive crops to affected farmers.

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## Case 5

## EXTREME HEAT, DROUGHTS AND WITH ANNUAL OCCURRENCE OF FLASH FLOODING

## Location: The village of Sepaka, Island of Mindanao, Southern Philippines[13]

Extreme climate variability conditions such as during the occurrence of El Niño and La Nica events have greatly affected the spatial and temporal distribution of rainfall in tropical rice-growing areas such as the Philippines. The climate related events had been correlated with the decline observed in the rice production and productivity in the Philippines (PhilRice-BAS 2000).

> ***El Niño is characterized by major shifts in global precipitation patterns, associated with a weakening of the steady winds that blow from east to west above and below the equator (trade winds) and warming of the eastern Pacific Ocean, resulting in the formation of intense rain over the warm water.***
>
> ***(Lubomudrov, 1997)***

In the village of Sepaka on the island of Mindanao, the adverse impact related to climate change had led to the presence of regular pest infestations and unpredictable weather affected rice production, and hence threatened food security in the village, and the province.

The occurrence of extreme climate variability such as El Niño or La Niña events characterized by a prolonged dry period or heavy rainfall spell coinciding with the critical stages of crop growth and development may lead to significantly reduced crop yields and extensive crop losses.

Once known as the food basket of the Philippines, Mindanao has the past few years been battling annually with extreme heat, droughts and flash flooding. The rice farmers could no longer enjoy the three

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13. Oxfam America 2007

planting seasons a year due to unpredictable climatic related conditions (Mamid, 2007).

Since the 1997 El Niño, the village of Sepaka experienced one of the worst drought period in 2006 which lasted for six months. Subsequently, another climate-linked problem appeared in 2007 many of the rice fields in the village turned black and dried up because of an infestation of Rice black bugs (RBB).

***The Indian El Niño - associated Monsoon in 1997 turned out to be reasonably good, with country wide seasonal rainfall at 102 per cent of the long term average.***

***Even though the monsoon was delayed by a week, the cumulative rainfall was excess or normal covering 81 per cent of the districts of the country.***

***(India Budget 1998)***

The Rice Black Bugs (RBB) or *Scotinophara coarctata,* attack rice stems, infesting the bases of rice stems and draining their saps causing the plants to weaken. This process eventually causes the stalks to wither (bug burn) and die (Cebu Daily News, 2006).

## Adaptation Strategies

The concurrent events of droughts on rainfed lands, resulting in poor harvests due to black bugs in the past years deleteriously affected the people. To reduce the socio-economic impacts and agricultural losses due to climate-associated situations, farmers in the village adopted organic farming methods. An Oxfam project had allowed farmers to venture into organic farming techniques to help their village cope with a changing climate. The training received through Oxfam's Projects had taught farmers to prepare organic pesticides and fertilizers, thus reducing costs and dependency on synthetic or chemical alternatives. The organic farming methods have enabled the fields to withstand rice pests, intense flash floods and recurring droughts. Eventually, farmers were able to grow more and greater variety of crops such as squash, string beans and other vegetables, improve soil fertility, and cut production costs by reducing reliance on expensive fertilisers and pesticides.

The government, on the other hand, ventured into a more commercial-linked solution. Through a formalized intervention, due to poor rice harvest, the people of Sepaka were convinced to convert their rice fields for the production of jatropha (Reyes, 2007). Inevitably, it was feared that the rush to plant oil palm or jatropha would aggravate food shortages and climate change (Reyes, 2007). It was also feared that sourcesof livelihoods from other activities such as employment as seasonal weeders, gleaners or harvesters or picking and selling snails and cogon grass would be lost with the intensification of palm oil or jatropha plantations in the area.

***A complete management practices were evolved for Rice black bug. Spraying neem seed kernel extract 5%***

***(TNAU, 2003)***

Photo by IRRI & University of Queensland

# Case 6

## DROUGHT IN 2006
## Location: Rice-growing provinces of Anhui, Hunan and Hubei, China[14]

Drought has become the single largest factor limiting rice production in North China and the rainfed areas of South/Southeast Asia. In 2006, China suffered one of its worst droughts in half-a-century. Crops in the rice-growing provinces of Anhui, Hunan and Hubei were wiped out as water levels in lakes, rivers and reservoirs dropped to historic lows.

*China plants nearly 30 million hectares of rice per year, yielding over 180 million tons.*

*(New Agriculturist, 2008)*

In 2004, the areas were planted with about 4.0 million ha. of japonica rice in Northeast (3.3 m ha) and Northwest (0.7 m ha.) China (Zhi-Khang, 2005). During the drought, average lowland rice yields dropped from 7.5 tons per ha. to 6.6 tons.

### Adaptation Strategies

**Aerobic rice** was introduced and promised to be the variety that significantly uses less water than ordinary lowland rice.

Aerobic rice requires much less water than ordinary lowland rice (Credit: IRRI)

Aerobic rice has been engineered by combining the positive traits of hardy upland rice with those of high-yielding lowland rice. Aerobic rice represents a new concept of growing high-yielding in non-puddled, aerobic soils under irrigation and high external inputs (Bouman *et al*, 2002).

Aerobic rice needs 50-70 per cent less water than lowland rice because of its longer roots that facilitate water absorption and improve air circulation. It also produces acceptable yields under flood conditions, if and when the floods hit.

***Two pilot site villages were established by IRRI in 2001 for farmer-participatory testing, site-specific adaptation and extension of aerobic rice, one near Beijing and one at Fengtai (Anhui province).***

***Though, on average, the yield of aerobic rice was 27-35% lower than that of flooded lowland rice, the water use was 55-66% lower, and water productivity 1.6-1.9 times higher.***

Field experiments and farmer-participatory research have been simultaneously carried out in many part of the world including in the Huang-Huai-Hai plain, northern China.

Highest recorded aerobic rice yields were 4.7-6.6 tons per hectare, compared with 8-8.8 tons of lowland rice. The variety Han Dao 502 seemed to be promising because of its relatively high yield

14. The New Agriculturist, 2008

under both aerobic and flooded conditions and because of its good quality could demand a high market price. Compared with lowland rice, water inputs for aerobic rice were more than 50% lower (only 470-650 mm),

### Catch-22 in adopting strategies related to weather conditions

Following the event of severe drought in 2006, China experienced severe floods beginning summer of 2007 (Vision Voice, 2007). Areas such as Guangxi, Guizhou, Hunan, Sichuan, Anhui, and Shaanxi, that were plagued with droughts in 2006, were later badly affected by floods. The impact assessment in Anhui reported that prolonged heavy rainfall had literally turned all land into a lake whereby many houses and almost all farmlands were submerged. Aerobic rice which requires less water is not an appropriate alternative during rainy seasons. In this case, a variety that is able to grow submerge in water might be appropriate. The flood situations in the affected provinces led to the distribution of over 2,100 metric tonnes of rice with a total of 140,000 beneficiaries (Vision Voice, 2007).

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## Case 7

## HIGH SALINITY LEVEL OF RAINFED RICE FIELDS
## Location: Isaan region, Thailand (Khon Kaen province)

The climate in Khon Kaen Province, Thailand, generally depends on the pattern of monsoon each year. Summer normally starts from mid February to the end of May with the annual average highest temperature of 34.07$^{0}$C; the highest temperature in 2000 was recorded at 41.7$^{0}$C. The rainy season starts from May to early October with the precipitation of 1,683.3 mm for 108 raining days in the year 2000. Normally the heavy rain concentrates on August and September. Winter normally starts from December to mid of March with an annual average minimum temperature of 21.7$^{0}$C; the minimum temperature in 2000 was recorded at 12.1$^{0}$C. However, in 2002 it was expected that north eastern Thailand would be affected by El Niño.

From the total land area of 6.80 million rais (about 1.08 million hectares), 61.86% were utilized for agricultural purposes in 2001. Most of the lands were utilized for rice cultivation especially glutinous rice for household consumption. Rice cultivation needs a lot of water, during the rainy season. More than 2.5 million rais were utilized for the first crop of non-glutinous and glutinous rice. For the second crop, only 134,046 rai of irrigated land were feasible for rice cultivation. For the first crop, the average yields of non-glutinous and glutinous rice per rai are 448 and 436 kg/rai respectively. The reason for low yield per area has been attributed to the nature being rainfed areas. For the second crop, only small-irrigated areas are normally utilized, the average yields per rai are as high as 644 and 603 kg/rai respectively. In 2001, Khon Kaen produced 1,110,232 ton of paddy for the first crop and another 85,106 ton for the second crop. The other main crops of Khon Kaen are cassava, sugar cane, soybean, maize and ground nut.

***Thailand considered a 3-mechanism approach in its crop improvement strategy that influence yield in the drought prone areas:***

***i) yield potential as an important mechanism for mild drought (where yield loss is less than 50%),***

***ii) drought escape (appropriate phenology)***

***iii) drought tolerance traits (leaf water potential, sterility, flower delay and drought response index) for more severe drought conditions.***

***(Jongdee et al, 2005)***

## The Problem

The high salinity level in the soils in Isaan region has been attributed to natural phenomenon such as climate, rock salt deposit, saline groundwater (Japakasetr and Workman 1981) as well as by human activities including wood cutting, water storage, and groundwater pumping (Williamson *et al.,* 1989). In Northeast Thailand, salt affected areas are often found in rainfed paddy fields. Salt accumulation in the region is caused by transpiration of saline groundwater (Khoyama *et al.,* 1993). Salt that causes damage to vegetation is transported from salt sources such as rock salt and brine to the ground surface due to salt accumulation by leaching. This led to the abandonment of many agricultural fields.

Soil salinity refers to the state of accumulation of soluble salts in the soil. Soil salinity can be determined by measuring the electrical conductivity of a solution extracted from a water-saturated soil paste, generally has an ECe more than 2 $dS.m^{-1}$ at 25°C (Richards, 1954).

## Natural Causes of Salinity

Salinity may be caused by natural processes such as rainfall, humidity, evaporation rate, topography, discharge and recharge area conditions and groundwater flow systems of the region. Naturally, the development of saline soil and saline groundwater is related to the flow of groundwater. Under saturated flow conditions, when the moisture content is at or above field capacity, groundwater is able to move under the influence of gravity. In saturated flow systems, excess of groundwater builds up in a recharge area to the point where lateral groundwater flow occurs. As the groundwater flows between particles of rock and soil, it dissolves and transports soluble salts. The groundwater emerges at the soil surface in a discharge area. When the water evaporates, the salts are left behind on the soil surface. Over time, the salts accumulate in the discharge area, and eventually the salt concentration becomes so high that plant growth is restricted.

In 1993, severe salinity level of soil in Kula Ronghai (Ki) at Nakhon Ratchasima province, Udon (Ud) at Mahasarakam province, and Roi-et (Resaline) at Khon Kaen province were recorded at 20, 23 and 15 ds/m in rainy season and 100, 42, and 35 ds/m in dry season, respectively.

However, various investigations conducted suggested that the salt-affected areas have been expanding mainly due to human activities such as deforestation, salt making, irrigation and construction of reservoirs, canals and roads (Wada *et al.,* 1994). That implies that inadequate management of agricultural land use accelerates salt accumulation.

The salinization of rice paddies and water reservoirs is a very recent development and is associated with deforestation in the upland soils for producing cash crops as cassava and kenaf. Subsequent changes in the hydrologic conditions following land clearing and replacement of deep rooted trees with shallow rooted crops (cassava, kenaf, etc.) increased the natural recharge of aquifers and resulted in saline seepage on lower slopes and valley floors.

Visual indications of high soil salinity in Northern Thailand include both the presence of salt- tolerant indicator shrubs such as Nham Daeng, Nham Phung Dor, Nham Phrom and Nham Pee and salt-tolerant grass as Sakae and the absence of productive plants such as rice and maize that are unable to tolerate saline conditions.

The high soil salinity decreased annual crop yields (Yuvaniyama et al., 1996).

## Adaptation strategies

Strategies adopted to grow rice on high soil salinity include:

**i) Pumping groundwater for irrigation**

The use of groundwater for agriculture is mainly to supplement surface water supplies. In Thailand, pumped irrigation schemes have been implemented by the Department of Energy Development and Promotion to secure adequate irrigation water.

**ii) Reforestation Program**

Recognizing the impact of salinity, the Thai government has introduced a long-term reforestation program, allo-

**Table 2. General ranges for plant tolerance to soil salinity.**

| Salinity (ECe, dS.n$^{-1}$) | Saline Level | Plant response |
|---|---|---|
| 0 to 2 | Non saline | Mostly negligible |
| 2 to 4 | Slightly saline | Growth of sensitive plants may be restricted |
| 4 to 8 | Moderate saline | Growth of many plants is restricted |
| 8 to 16 | High saline | Only tolerant plants grow satisfactorily |
| > 16 | Extreme saline | Only a few, very tolerant plants grow satisfactorily |

cating approximately 5 million rai for tree planting in the 1992-1996 Development plan.

iii) **Deliberately facilitate water and solute transfer within 2-meter soil depth** (Montoroi, 2006). French organization IRD and Land Development Department (LDD) from Thai Ministry of Agriculture and Cooperatives has carried out since three years a local field experiment (LFE) based on water and solute transfer monitoring at short-time steps within two meters soil depth and on the salt-affected soil rehabilitation using improved cultural practices (Saejiew, 2003).

iv) **Water storage**

v) **Deep-well injection of brine** (ACIAR, 1992)

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## Case 8

## THE DRY SEASON AND FOREST FIRE
## Location: Central Kalimantan, Indonesia[15]

The largest land conversion scheme was the Mega Rice Project in Central Kalimantan in 1996. Dubbed as the brainchild of former President Suharto, the project was an illustration of poor environmental management which aggravates climate change.

The Mega Rice Project (MRP) in Central Kalimantan, Indonesia, was implemented in 1996 with the aim of converting one million hectares of tropical rain forest on peat lands into paddy field and promoting transmigration. The combination of forest destruction, land clearance and an exceptionally severe El-Niño climatic event in 1997 led to the severest forest and peat-land fires ever known in this region.

Since 1983, Indonesia has been greatly affected by annual climate variability due to El Niño or Southern Oscillation events, commonly taking place in the Pacific Ocean every two to seven years. During a warm El Niño, the arrival of the monsoon rains would be delayed, disrupting the planting of the main December-January crop.

In 1997, El-Niño event caused very severe and abnormal drought lasted for few months in the Kalimantan

***Southeast Asia contains 70% of the world's total tropical peatland, mostly in Indonesia and Malaysia.***

***(Rieley, 2001)***

***Indonesia is rated as the third largest $CO_2$ polluter in the world.***

***Carbon emissions from the 1997/98 fires amounted to an estimated 15-40% of annual global fossil fuel emissions***

***(Kieft, 2007)***

15. Hohan, 2007

that eventually turned disastrous with severe peat fires. Severity and abnormality of drought under El-Niño event were found to have strong relationship to the Sea Surface Temperature (SST) anomalies.[16]

Coupled with the drought, the poor management of the peat lands has also been associated with climate change because of high level of $CO_2$ emission from decomposition and burning (smoke and haze). With the implementation of the MRP, thousands of kilometers of drainage and irrigation channels were built that caused the peat to dry up.

The damage in the ecosystem (e.g. soil fertility) as a result of this activity had cost farmers their livelihoods. Farmers resorted to use fire as an essential low-cost tool for clearing land and releasing nutrients.

Due to the rampant activities of open-burning on rice fields to clear land and release soil nutrients on the island, the Indonesian government ultimately had to intervene and pass a "No-burning Legislation" to reduce haze and emissions. This legislation had made farmers vulnerable to legal problems where they could be detained and fined for setting fire on their farm land, which almost all depended on for livelihoods.

The negative results surrounding the project eventually led to its termination. Unfortunately, the strategy adopted in combating the adverse effect of climate change led to implementation of the “No-burning Legislation”, which backfired on poor farmers.

***Between 1997 and 1998, fires raged across Indonesia causing an estimated US$ 4.5 billion in damage. The fires spread smoke as far as southern Thailand and the Philippines.***

***(ICRAF, 2003)***

***The Indonesian Environmental Impact Management Agency (BAPEDAL), the secretariat of a National Coordinating Team for Land and Forest Fire Control (TKNPKHL), established an emergency command post (POSKO) to coordinate efforts to control land and forest fires during the extended dry period in 1997.***

***(IFFN, 1998)***

***Malaysia amended its Environmental Quality Act 1974 (EQA) in July 2000 to address problems related to open burning.***

16. Putra & Hayasaka, 2007

## Case 9

# GRADUAL INCREASE IN SEA LEVELS, FORCING SALTWATER FROM BAY OF BENGAL INTO LOWLAND

## Location: Small Village Of Munshiganj, Southwestern Bangladesh[17]

Recently, the rising of sea level has been closely associated with global warming causing thermal expansion of the ocean waters and the melting of land-based ice (the Himalayan glaciers).

> ***Strange events of 2004 in Bangladesh experienced through the tides in the estuaries of the Ganges, Brahmaputra and Meghna rivers stopped ebbing and flowing. The water level just remained at high tide.***
>
> ***And in 2005, Bangladesh had no winter at all.***
>
> ***(The Independent, 2007)***

Bangladesh being situated in one of the world's highest precipitation areas is prone to flooding due to various factors including its low topography. In addition, Bangladesh has the world's biggest rivers flowing through it, and experiences the occurrence of cyclones. Various measurements taken in different points in Bangladesh suggested that 70% of its land area lies less than 1m above sea level (GeoBytesGCSE, 2006).

Not surprisingly, a climate change disaster for Bangladesh could be well demonstrated by rising sea levels that often caused flooding in most part of the country. The flood in 1987 affected 39% of the country and around 30 million people. Loss in rice production was estimated around 0.8 million tons. The following year, in 1988, 60% of the country was affected, along with 45 million people and 1.8 million tons in rice production. Between July and September 1998, another disastrous flood hit Bangladesh, where water was reported to rise to 6 meters above mean sea level due to high discharge and tide (GeoBytesGCSE, 2006).

Due to frequent flooding caused by inland flow of sea water, many parts of Bangladesh eventually suffered from high salinity in the groundwater. Water salinity is defined by its chemical constituents, and Total Dissolved Solid contents (TDS, mg/l). In natural water, salts are chemical compounds comprised of anion such as carbonates, chlorides, sulfates, and nitrates (primarily in the groundwater), and cations such as potassium (K), magnesium (Mg), calcium (Ca), and sodium (Na).

### Adaptation Strategies

Rice farmers around the coastal area have begun to suffer from the effects of rising salinity. The water in their paddy fields had become salty, thus could no longer be suitable for rice cultivation. Due to this change in the environment, the farmers changed their agricultural practices. Many farmers in the village of Munshiganj, for

17. The Independent UK. 2007

example, who used to harvest rice and vegetables 2-3 times a year, switched to prawn farming to take advantage of the salty water to continue sustaining their livelihoods and incomes.

The increasing concern on the rising level of water salinity and its impact on rice production prompted Bangladesh to embark into developing a new strain of rice that has the capacity to withstand salty water. The impact of water salinity on rice production in Bangladesh is obvious from its current yield capacity which is only half of China. Bangladesh farmers could produce around 8 tons of rice per hectare, compared with 17 tons in China (Huggler, 2007).

Bangladesh has continuously sought for long term measures for defence against or coping with the rising sea levels that often caused flooding. These measures include huge series of dykes made of boulders that stretch along the entire coast. Since 1957, about 7,500km of flood embankments have been constructed and yet many were compromised or damaged in the 1998 floods. The government also constructed flood protection shelters (large buildings raised above the ground) to shelter both people and animals. Emergency flood warning systems and plans has also been put in place to facilitate rescue and relief services. The government bodies also distributed free seeds to farmers in order to reduce the impact of food shortages.

For Bangladesh, where agriculture makes up 21 per cent of GDP for around 147 million people, the rising levels of salinity, caused by rising sea level associated with climate change, is a serious threat.

# ANALYSIS AND CONCLUSIONS

Various strategies were adopted by farmers, communities, agencies or governments in the efforts to combat the adverse impacts of climatic conditions that affect rice farming.

Behind these recommendations and implemented strategies, it is interesting to understand the underlying purpose of strategies adopted. The various objectives or goals of the adopted strategies could work for the benefits of either one or in combination of the following:

- Farmers
- Agricultural / farming sector
- Country's Economic growth (GDP)
- Rice sector
- Environment

In the last case mentioned, for example, it is obvious that the strategy adopted worked against rice production, as the people abandoned the rice activities and shifted to prawn farming. This means that the world has lost an area for rice production, hence might contribute to shortage of rice supply, domestically or globally. However, the livelihoods of the farmers were protected as they have identified another source of income.

The stability of rice production systems in tropical agro-environment depends on adaptation strategies and mitigation measures applied to cope with these events. As such, it is important to evaluate the effects of climate change on rice crop growth and development. Crop management measures include a wide range of possible strategies. However, more emphasis, as well as research and development, should be put on sustainable approaches such as:

- A multi-cropping system approach rather than a single crop development approach.
- Motivating the farmers to provide life saving irrigation to the crop wherever possible during long dry spells.
- Improving soil fertility.
- Emphasis on balanced use of plant nutrients along with the integrated plant management system.
- Use of bio-fertilizer.
- Effective control of pests and diseases by emphasizing the need based application of pesticides or complete management using bio-pesticides.

| Strategies | Reason / Problem |
|---|---|
| Change varieties (High yield variety, Strong stem variety, Disease resistant, Drought tolerant, etc) | Non saline |
| Change cultivation area | Infertility, salinity |
| Diversify | Expand sources of income, soil or water management |
| Crop rotation | To improve soil fertility, to suit climatic conditions (seasonal weather) |
| Systemize irrigation (water ponds) | Improve water management and supply to low - land rice fields. |
| Drainage | Mitigate flooding problems |
| Aerobic cultivation | Drought, poor irrigation |
| Alternate wet and dry system | Increase income potential, take advantage of seasonal weather |
| Rice intensification (SRI) | To reduce production cost, minimize environmental damage, increase productivity. |
| Farming techniques | Increase efficiency, productivity |
| Equipment or Mechanization | Labor-constraint |
| Inputs (fertilizers, pesticides) | To enhance yields |
| Farm animals | Reduce cost of production, organic soil management, |
| Tree planting (buffer zone, rooting) | To mitigate climatic impact, to stabilize soil |
| Change planting and harvesting dates (crop management) | To reduce socio-economic impacts due to climatic variability, taking advantage of conducive growing conditions. |

- More emphasis on the adoption of non-monetary inputs like timely sowing, maintaining optimum plant population, timely irrigation, efficient use of organic inputs, plant protection measures and timely harvesting of crop.

The impact of climate change on agriculture has generated great concern worldwide. The International Assessment of Agricultural Science and Technology for Development (IAASTD) Report in April 2008 clearly provided evidence for the impact of climate change on farmers. In understanding the severity of CC impacts on farming communities and the various new technologies that have been recommended, including "for farmers to adopt these (agricultural) technologies (to mitigate and adapt to climate change) substantial financial support will be needed….farmers should be given monetary credits for the GHG emissions reduced..."

***"For hundreds of years, natural selection pressures such as drought, submergence, flooding, and nutrient and biotic stresses led to a great diversity in rice ecosystems."***

***(FAO, 2004)***

Some cases in this report showed that many efforts have been geared on the manipulation of rice plants in order to withstand different climate-associated conditions. It is important to note that the IAASTD Report also addressed the possible consequences of modern biotechnology and genetically-modified organisms (GMO), whereby "It is still if and under what conditions they actually improve yields, as both gains and declines have been reported. Because new techniques are rapidly being developed, longer-term assessments of environmental and health risks and benefits tends to lag behind discoveries."

# Annex 1:
# SOME FACTS ABOUT RICE[18]

- Asia is responsible for the production and consumption of more than 90 percent rice in the world. Rice being the staple diet of half the world's population is typically eaten two or three times daily.
- An average Asian consumes about 150 kg of rice annually. An average European eats around 5 kg.
- Rice farming has been traced back to around 5,000 BC.
- Asia is home to 250 million rice farms. Most are less than 1 hectare.
- 65 kilos of rice are milled annually for every person on earth.
- Millions of the poor spend half to three fourths of their incomes on rice.
- To produce one kilogram of irrigated rice, around 5,000 liters of water is required
- More than 140,000 varieties of cultivated rice (the grass family Oryza sativa) are thought to exist but the exact number remains a mystery.
- Three of the world's four most populous nations are rice-based societies: People's Republic of China, India, and Indonesia. Together, they have nearly 2.5 billion people almost half of the world's population.

18. Extracted from Rice Trade B-2-B Marketplace, 2008.

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