# Rethinking Agriculture in the Greater Mekong Subregion

## How to sustainably meet food needs, enhance ecosystem services and cope with climate change

IWMI
International Water Management Institute

WorldFish Center

Funded by:
Sida

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## Credits

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This summary report is based on:

Johnston, R.M.; Hoanh, C.T.; Lacombe, G.; Noble, A.; Smakhtin, V.; Suhardiman, D.; Kam, S.P.; Choo, P.S. 2009. Scoping study on natural resources and climate change in Southeast Asia with a focus on agriculture. Report prepared for the Swedish International Development Cooperation Agency by the International Water Management Institute. 118p. doi:10.3910/2010.201

Sources for data used in diagrams, plus key references, are provided on page 23.
For a full list of references, please refer to the full scoping study at:
http://publications.iwmi.org/pdf/h042414.pdf

Johnston, R. M.; Hoanh, C. T.; Lacombe, G.; Noble, A. N.; Smakhtin, V.; Suhardiman, D.; Kam, S. P.; Choo, P. S. 2010. Rethinking agriculture in the Greater Mekong Subregion: how to sustainably meet food needs, enhance ecosystem services and cope with climate change. Colombo, Sri Lanka: International Water Management Institute. 26p. doi:10.3910/2010.207

/ agricultural production / rice / fisheries / livestock / farming systems / coastal area / flood plains / climate change / environmental effects / food production / ecosystems / water management / Mekong Subregion / Southeast Asia /

ISBN 978-92-9090-724-4



Cover image: A farmer tends his vegetables in Lao PDR / Chu Thai Hoanh
Photo credits: All photos www.iStockphoto.com unless otherwise stated

Editorial consultant: Carolyn Fry
Designer: Mario Bahar, Gracewinds Advertising
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Printer: Printel Private Limited

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## Contents

## Main messages and recommendations

### Southeast Asia's agriculture is changing

Agriculture in the Greater Mekong Subregion (GMS) (see Figure 1, overleaf) is shifting from traditional subsistence to modern commercial farming. Countries in the region are following a path of intensification, specialization, increased agrochemical use and mechanization, at varying paces. Agricultural production has increased steadily during the past 20 years, as a result of farmers adopting 'green revolution' technologies. Trends observed in the more developed nations, such as Thailand and China, are likely to emerge in less developed countries in the future.

### Population growth, social change and global trade will drive more changes

In the next 20 to 30 years, agriculture will be shaped by a complex mixture of social, economic and environmental pressures, with climate being just one of many factors contributing to change. Food production trends will primarily be influenced by: increased demand prompted by rising populations and dietary changes favoring meat and vegetables; urbanization, offering farmers opportunities to diversify but also putting pressure on water supplies; unpredictable global trends such as fluctuations in oil and food prices, plus the recent global economic crisis; and global investment and trade, particularly China's increasing imports and investment in plantations. Fisheries will also be affected by changes in river flows due to hydropower and irrigation developments.

### Climate change impacts are uncertain

Scientists predict that climate change will affect the GMS only moderately in the period to 2050. The changes forecast include rising temperatures and some seasonal shifts in rainfall, with wetter wet seasons and longer, drier dry seasons. Beyond 2050 the rise in temperature will speed up and sea-level rise will accelerate to reach at least one meter (m) above current levels, posing a great threat to farmland in the coastal and delta regions. Climate forecasts are highly uncertain, so governments must take action to build resilient communities that can cope with unforeseen circumstances. People's capacity to adapt to change is closely linked to wealth, diversification of income sources, education and access to infrastructure and technology. Promoting broad-based agricultural development to lift deprived rural communities out of poverty is probably the most effective adaptation strategy available.

### Using water efficiently is the key to future food security

Much of the agricultural land in the GMS is prone to floods, droughts or both. Agriculture, urban centers and industry will increasingly compete for water needed to maintain aquatic ecosystems, while climate change may increase the uncertainty of water availability. Around 75% of crops are rain-fed. In many areas, irrigation is not technically or economically feasible, so improving water management is essential. Using conservation farming techniques, plus harvesting and storing run-off on farms, can achieve this. Public irrigation schemes often perform well below their potential due to inappropriate design, operation and maintenance, and improving their performance and flexibility must be a priority. A comprehensive assessment of groundwater potential and use in the region is urgently needed.

### Natural ecosystems must be restored and protected

Natural ecosystems underpin production within agricultural, aquacultural and wild-catch fishing industries, and provide a range of other ecosystem services such as flood control, mediation of water quality and biodiversity. Many poor communities rely on fisheries, wetlands and forests for significant proportions of their food and livelihoods. Meeting additional food demands will not be possible without restoring and safeguarding natural ecosystem functions.

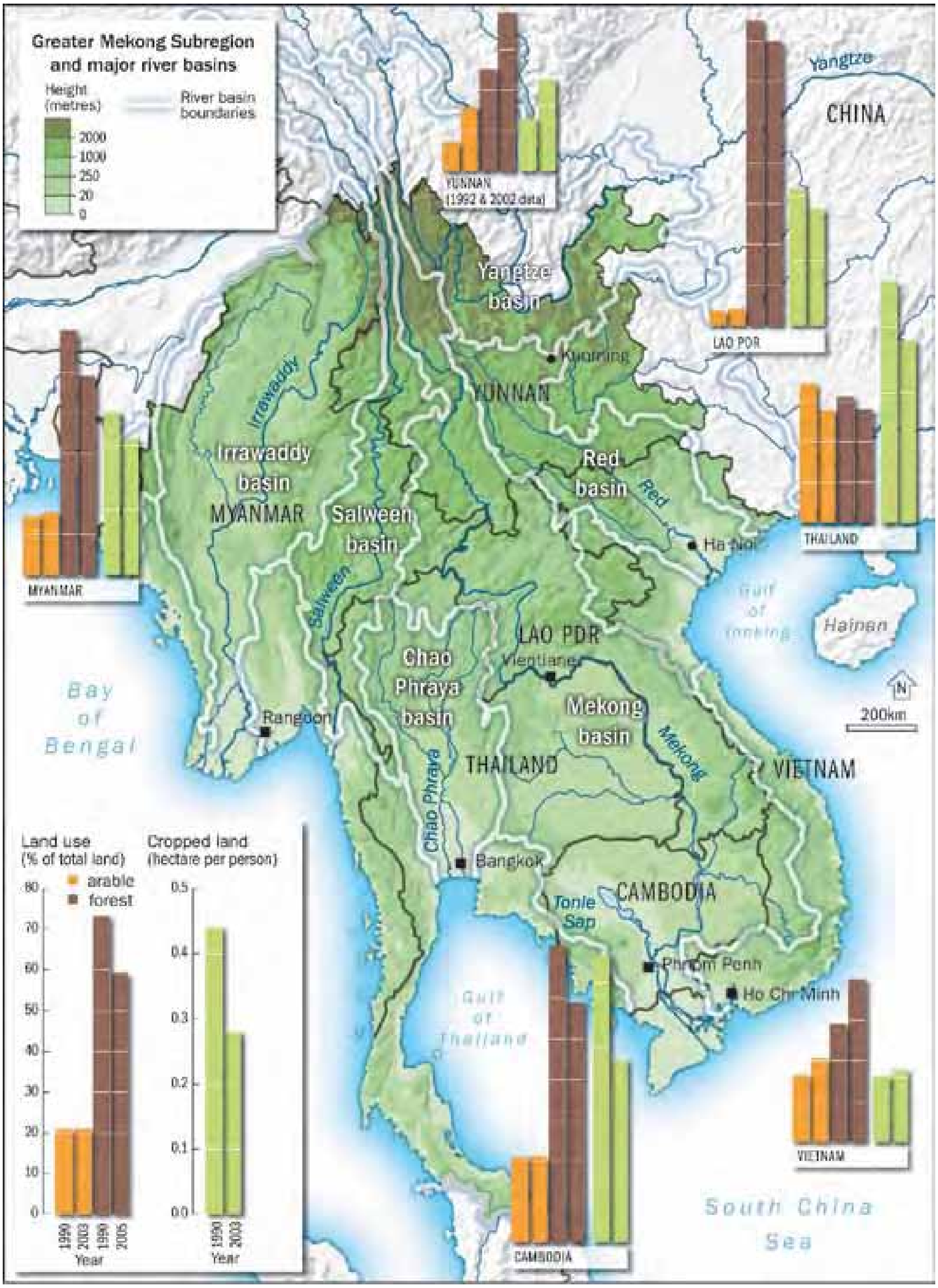
### To provide sufficient food, governments must 'rethink' agriculture

Given that recent increases in food production in the GMS have come at great cost to the environment and without considerably reducing rural poverty, agriculture now needs an overhaul. To meet future food needs, agriculture must be transformed to deliver food security, ecosystem services (such as clean water, flood protection and carbon sequestration), economic growth, and resilient rural communities. Achieving these goals will demand innovative farming methods and technologies, more efficient use of water, action to protect and restore ecosystem services, plus greater opportunities for the poor.

**Figure 1**

**RIver and land-use characteristics of the Greater Mekong Subregion**

Source: Greater Mekong Environment Outlook (UNEP and TEI 2007)



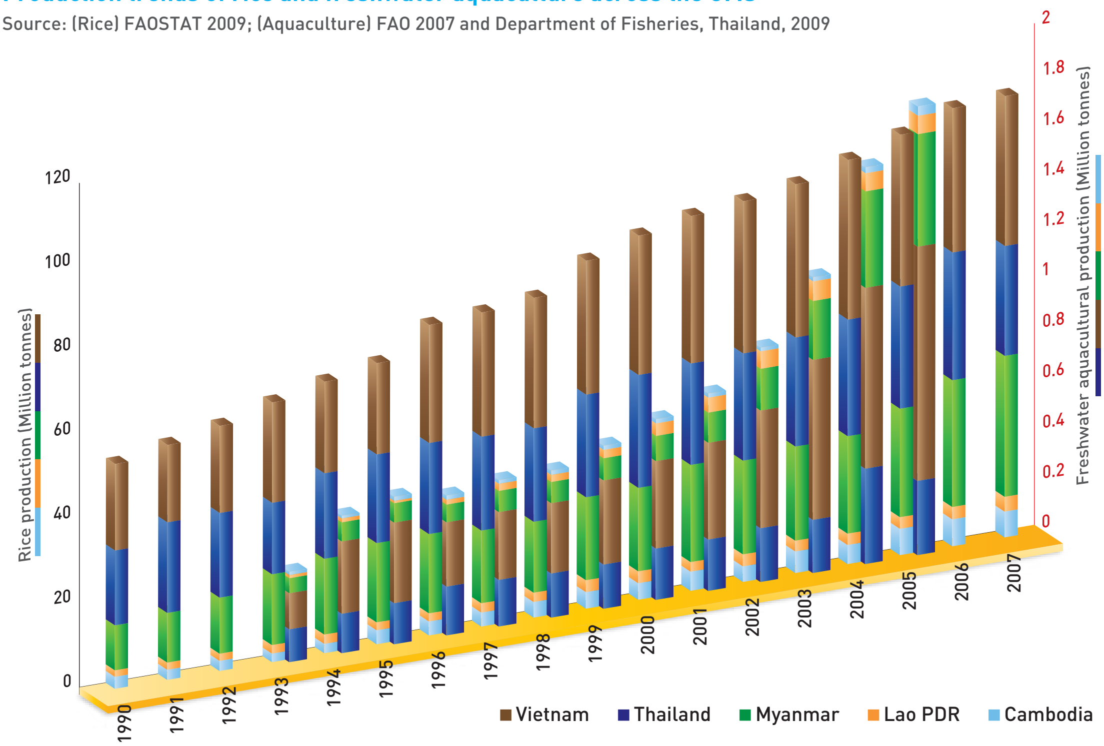
Southeast Asia's agriculture is shifting from traditional subsistence farming to modern commercial farming practices. Although individual countries and subnational regions are progressing at vastly different paces, they are generally following a path of intensification, specialization, increased agrochemical use and mechanization. Trends observed in the more developed nations, such as Thailand and China, are likely to emerge in the less developed countries in future.

Agricultural production has steadily increased in all countries of the GMS in the past 20 years. Production in commodities such as rice, oil crops (soybean, groundnut, sesame and sunflower) and coarse grains (maize, millet and sorghum) has more than doubled since 1990, outpacing the region's rapid population growth (see Figure 2). Many farmers have switched from growing rice to producing commercial crops, such as fruits, vegetables, rubber and pulpwood.

## Figure 2

### Production trends of rice and freshwater aquaculture across the GMS

Source: (Rice) FAOSTAT 2009; (Aquaculture) FAO 2007 and Department of Fisheries, Thailand, 2009




The increase in crop production reflects the farmers' adoption of 'green revolution' approaches and technologies rather than land expansion. These approaches include more effective irrigation, improved plant varieties, increased use of fertilizer and better farming practices. The increased production of 50% from small livestock, 45% from cattle, 300% from brackish-water aquaculture and 500% from freshwater aquaculture is a consequence of intensification and an increase in the production area.

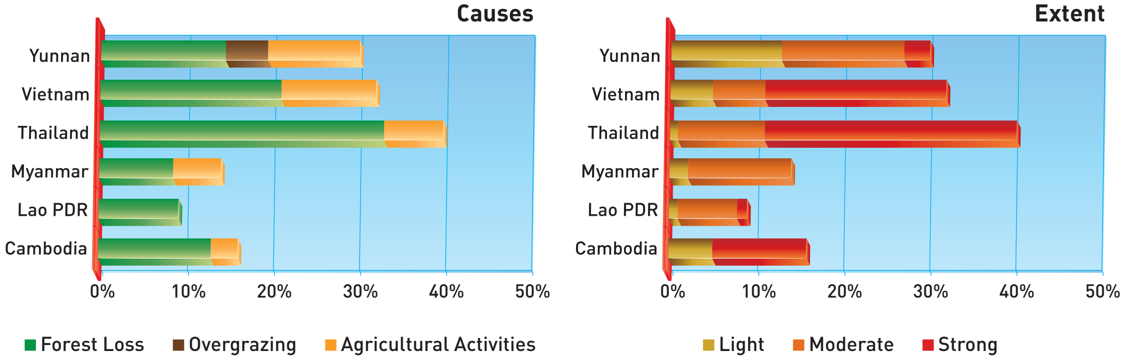
These dramatic production rises have come at an environmental cost. According to the Greater Mekong Environment Outlook, land degradation affects between 10 and 40% of land in each country in the GMS (see Figure 3, overleaf). Forest loss, agricultural intensification and overgrazing (in Yunnan) are the main causes for this. Changes to artificial landscapes associated with farming activities have disrupted vital natural services by reducing the capacity of ecosystems to contain floods, control erosion and limit damage from pests.

Agriculture is the largest user of water in all countries in the GMS, consuming between 68 and 98% of total withdrawals. By altering natural flow regimes, irrigation development has affected fish populations and wetland habitats. Resulting dry-season water shortages have increased competition for water, especially in intensively-irrigated areas such as Vietnam's Red and Thailand's Chao Phraya deltas. Hydropower schemes planned for the Mekong, Salween and Irrawaddy rivers will disrupt natural flows further, with implications for farming and fisheries. Blocking migration paths with dams, for example, prevents fish reaching spawning and feeding areas.

## Figure 3

### The extent and causes of land degradation in the GMS

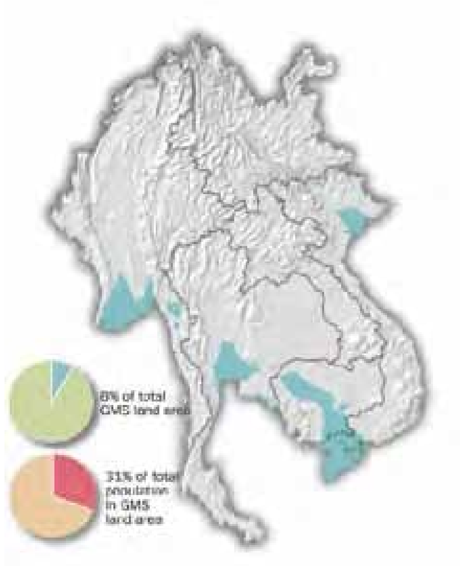
Source: UNEP and TEI 2007




CHU THAI HOANH / IWMI

## Features of the Greater Mekong Subregion

The GMS comprises five agroecological zones that have common farming systems and are subject to similar geographical constraints and risks. The zones are not rigidly defined, but provide a helpful way to discuss agricultural systems at a regional scale.




### Deltas and Tonle Sap floodplain

The Tonle Sap floodplain and mega-deltas of the Red, Mekong, Chao Phraya and Irrawaddy rivers represent around 8% of the total GMS land area, but house over a third of the total population, some 86 million people. Rural population densities are high, and each delta hosts a major city. These cities offer opportunities to farmers, providing markets through demand for horticultural crops and meat, and alternative income sources. The deltas are the rice bowls of the countries, but are nearing full production, with problems of intensification, flooding and high population density.

The deltas represent a range of development from the Tonle Sap floodplain and Irrawaddy River, with limited irrigation and lower populations, to the densely settled, intensively farmed Red and Chao Phraya deltas, producing two or three crops a year. The Red, Mekong and Chao Phraya deltas have highly developed irrigation infrastructure (dykes, levees and canals to divert and retain water), but they all suffer water shortages in the dry season. For example, in the Mekong Delta in Vietnam, more than 80% of dry-season flows are diverted for irrigation, resulting in local water shortages and seawater intrusion.

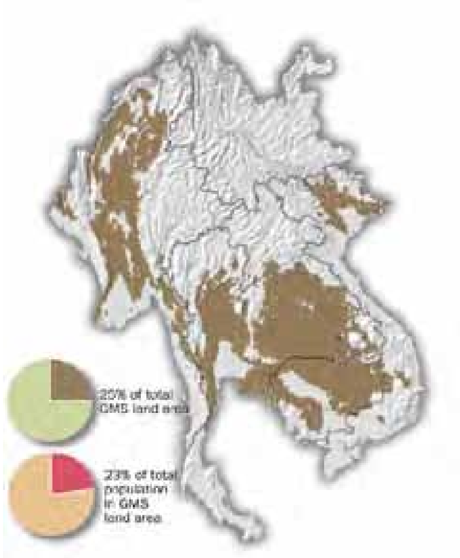
Rice is the major crop; the deltas produce almost half of the GMS's rice. Although it is likely to remain the dominant crop, some deltas are beginning to grow a wider range of produce. For example, only 60% of land in the Chao Phraya Delta is now planted with rice; one million hectares (Mha) of alternative crops, mainly sugarcane and cassava, are grown, primarily for export. In the Red River Delta, 40% of land produces non-rice crops in the winter. The by-products of rice farming support large herds of cattle, buffalo, pigs and poultry.

The deltas support extensive marine and inland capture fisheries, as well as rapidly expanding brackish and freshwater aquaculture. The Mekong Delta accounts for 70% of Vietnam's aquaculture production and 63% of its marine capture. The Tonle Sap floodplain is particularly important because of its productivity and link to the inland fisheries of the Lower Mekong Basin, including Cambodia, Lao PDR and Vietnam (see box below). Here, inland capture fisheries dominate; and aquaculture is minimal.

#### Tonle Sap: Rural life-support

The Tonle Sap Region, around Great Lake in Cambodia, is critical to the biodiversity of wild fish stocks. It is the breeding ground for around 300 species that support the inland capture fishery of the Lower Mekong Basin. The Tonle Sap fishery alone accounts for almost two-thirds of Cambodia's inland fishery catch, and is valued at US$233 million per year. This amounts to 7% of the country's Gross Domestic Product (GDP). Fish farming is critical to the food security and livelihoods of the rural poor; 31% of households surveyed in the Tonle Sap floodplains said they derive their main income from fishing, and 98% reported being involved in some kind of fishing activity throughout the year.

## Lowland plains and plateaus




Lowland plains and plateaus make up a quarter of the GMS and house 64 million people. Apart from sparsely populated northern Cambodia, population densities are moderate and poverty is widespread. The plains and plateaus represent a development trajectory from the forests growing in northern Cambodia through the partially irrigated extensive agriculture of the Isan Plateau to the highly irrigated Central Thai Plain.

Agriculture is mostly rain-fed, although annual rainfall is generally low. Lowland plains and plateaus produce a quarter of the GMS's rice, mostly in the wet season. In the dry season, farmers supplement wet-season rice by grazing livestock on the rice stubble, planting a second crop of irrigated rice, or growing irrigated sugarcane, maize, legumes, pulses or cassava. Large livestock herds of cattle and buffalo graze the plains and plateaus. Cattle are progressively replacing buffalo due to mechanization and dietary preferences for beef.

Large-scale plantations of oil palm, rubber, eucalypt, sugarcane, cassava and other industrial crops are increasing on the plains and plateaus. For example, by 2007, Lao PDR had granted concessions to 123 large plantations covering 165,794 ha. Sixty percent of these were located in the lowland plains of central and southern Lao PDR.

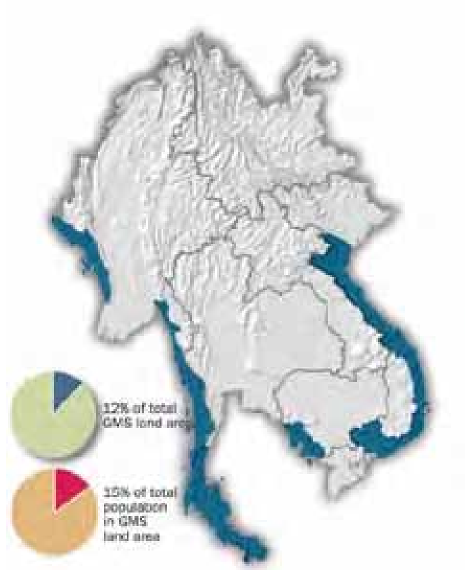
Wild-catch fishing on inland rivers, lakes and reservoirs is important to rural populations, especially in Cambodia, Lao PDR and northeast Thailand. However, experts fear hydropower developments on the Mekong and its major tributaries will disrupt migrations of species on which people in Lao PDR and Cambodia depend. Thailand and Myanmar, meanwhile, have reported increases in fish production in recent years. These are a consequence of improvements in managing aquatic resources, such as restoring and rehabilitating damaged environments, and restocking lakes and reservoirs.

There is minimal infrastructure on the plains of north and northeast Cambodia but all other GMS countries have invested heavily in irrigation; Cambodia, too, has ambitious plans to install irrigation infrastructure. Thailand's Chao Phraya Basin is highly developed with two large water storages and thousands of small dams and reservoirs. Around one-third of this 2.4 Mha command area is on the Central Plain. In Isan, several large hydropower-irrigation schemes and some 20,000 smaller schemes service an irrigable area of 1.4 Mha. Serious water shortages in both basins in the dry season prompt conflicts between urban, industrial and agricultural users.

Irrigation has expanded in Myanmar since the 1980s and now covers a quarter of the cropped area. Large-scale schemes are concentrated in Sagaing, Mandalay and Bago provinces. Smaller river-pumped, reservoir, river diversion and private village-based schemes make up the rest. In Lao PDR, more than 4,000 small to medium-sized schemes pump water from rivers. This irrigation infrastructure covers 190,000 ha during the wet season and 136,000 ha in the dry season. The government aims to double the irrigated area by 2020.

Lowland plains have been largely cleared for agriculture in Thailand and Myanmar, with the remaining native vegetation limited to higher, steeper land. Significant stands of forest remain in northeast Cambodia and southern Laos. These could potentially be converted to farmlands. However, poor soils are widespread, access to water is limited and the remaining forests have significant conservation value.

## Coastal zones




Narrow coastal plains rising rapidly to coastal ranges of 500 to 2,000 m make up 10-15% of Thailand, Myanmar and Cambodia, and over a third of Vietnam. Coastal rivers tend to be short and steep, with small watersheds.

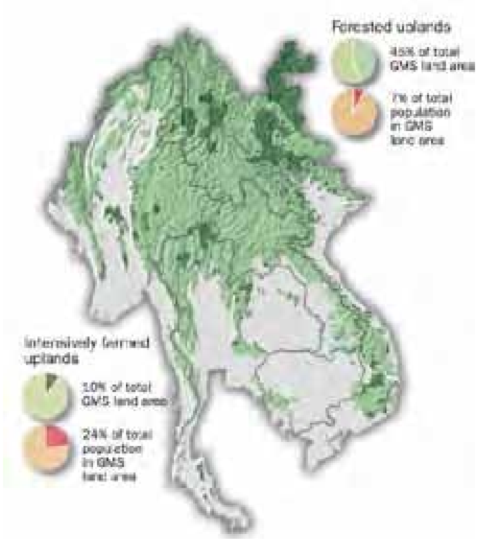
Coastal zones exhibit a range of agricultural systems, from paddy rice to rain-fed field crops (legumes, cassava, sugarcane and peanut), tree crops (fruit, nuts, eucalypt for paper pulp, jatropha and rubber), intensive cattle and pig farming, plus vegetable production. With farm sizes small and grazing areas limited, there has been a shift towards raising livestock intensively in combination with growing crops. Small-scale irrigation of rice and vegetables using rivers and groundwater takes place on the floodplains of coastal rivers. Plantations account for a quarter of the cropped area.

The coastal zones of all countries are important for capture fisheries, with annual landings estimated at 2.2 million tonnes (Mt). Marine fishing is mostly restricted to the shallower parts of coastal shelves. Large numbers of small-scale artisanal fishers catch multiple species, but large-scale commercial fisheries are dominated by non-local and foreign investors. Overfishing has prompted a consistent decline in the catch per unit effort. Marine- and brackish-water aquaculture is limited in non-deltaic coastal areas but there are opportunities for developing specialized culture systems in the cleaner waters along exposed coastlines.

Significant areas of forest remain in coastal parts of Myanmar and Cambodia but rates of deforestation and mangrove clearance are high. Little natural forest cover remains in Thailand, as a result of conversion to plantations since the early 1900s. Significant areas of forest remain in Vietnam but logging and thinning have taken their toll.

Erosion in the coastal uplands is exacerbated by flash flooding along short, steep coastal rivers. The sandy, low-fertile soils of the coastal strip make it hard for farmers to maintain productivity. Urban and agricultural pollutants reduce water quality in nearshore environments close to densely populated parts of Vietnam and Thailand. Pollution and the destruction of mangrove and coral habitats have affected fish stocks in the shallow waters fished by small-scale fishers.

## Intensively farmed and forested uplands




Over half of the GMS is hills and mountains. These uplands support 85 million people, of whom 46 million live in Yunnan, China (see box below). Two agricultural systems exist: intensive farming of highly productive, densely populated upland river valleys; and shifting cultivation and livestock grazing of sparsley populated forested terrains. This distinction is likely to remain, as large tracts of the forested uplands are steep, with poor, infertile soils. The boundaries between the two will shift as degraded soils return to forests and new lands come into production.

Intensive farming takes place on upland plains and in river valleys, which are often terraced for growing rice. The subtropical climate gives way to temperate conditions at altitude, enabling a wide range of plants to grow. Major food crops include rice, maize, vegetables, wheat and cassava. Important cash crops are vegetables, flowers, tobacco, coffee, sugarcane, tea, rubber, pepper, fruit trees, cocoa and mulberry. Farmers supplement irrigated wet-season rice with dry-season crops of faba bean, wheat, oil seed rape or sugarcane. They also raise livestock semi-intensively. Partial irrigation supports some cash crops including tobacco, vegetables and coffee. Using groundwater to irrigate coffee plantations in Vietnam's Central Highlands has depleted water supplies.

Traditionally, upland farmers derived their livelihoods from shifting or 'swidden' cultivation, livestock farming and by growing a limited number of cash crops. In forested upland areas, two swidden systems endure. 'Established' entails farmers cultivating trees, annual crops, cereals and legumes on a rotational basis, while 'pioneering' or 'slash and burn' involves clearing land and growing monoculture crops of cereals and legumes. The latter requires long fallow periods of eight to ten years, but with increasing population pressure this has decreased to between one and four years, resulting in erosion and declining soil fertility. Upland fishing is insignificant economically but provides valuable protein to communities.

Concerns about sustainability, the desire to locate populations in areas where services exist and various political and security issues have led all governments to introduce programmes to resettle ethnic minorities and eradicate shifting cultivation. These policies have prompted the expansion of permanent upland agriculture, often in unsuitable areas. Commercial plantations of rubber, timber and oil crops are also increasing, particularly in southern Yunnan, northern Lao PDR and parts of Myanmar. Wild-sourced timber remains an important economic sector in the uplands of Myanmar. A relatively high proportion of forest cover remains in the uplands, but it is shrinking. Rates of loss are high in Myanmar and Lao PDR but have stabilized in Yunnan and Vietnam, where replanting programmes have increased tree cover.

Intensive upland farming causes catchment-wide soil erosion. This decreases soil fertility and overloads waterways with sediment. Inle Lake in Myanmar has shrunk in length from 56 to 15 kilometers (km) during half a century. Plantations also prompt high soil erosion rates unless the understory is maintained.

### Yunnan's farming transition

In the past two decades, Yunnan's agriculture has switched from shifting cultivation to more commercially oriented fixed cropping. Yunnan farmers grow irrigated and rain-fed paddy in flat river valleys and on terraced slopes, and rain-fed rice on slopes. Improved rice varieties have lifted yields; for example, yields rose from less than 2 tonnes per hectare in 1990 to more than 3 tonnes per hectare in 2003. This has enabled farmers to diversify to cash crops with higher returns and, as a result, upland areas planted with rice have dwindled. The government has forbidden cultivation on slopes exceeding 25 degrees to reduce soil erosion.

## Climate change and agriculture

### Projected climate changes in the GMS

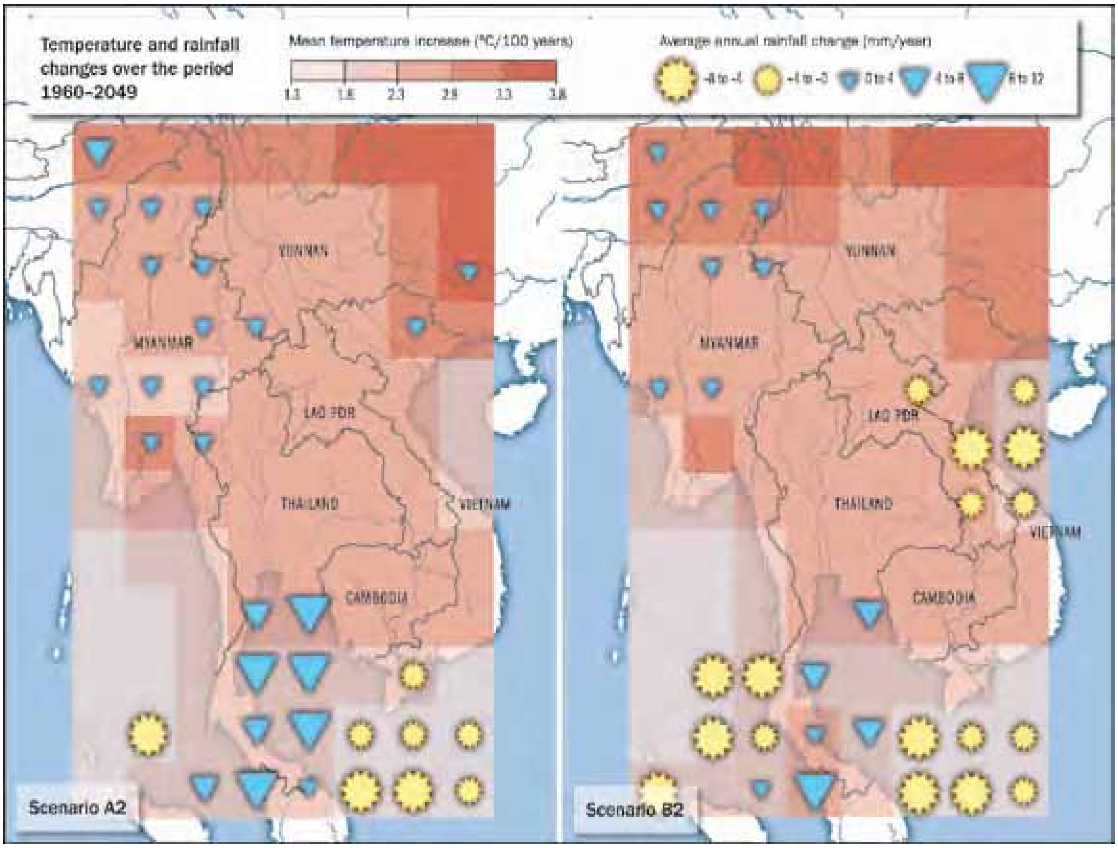
Results from studies carried out by IWMI and others in the GMS, anticipate the following main climate changes to 2050 (see Figure 4):

- Increase in temperature of 0.02 to 0.03 °C per year in both warm and cold seasons, with higher rates of warming in Yunnan and northern Myanmar;
- No significant change in annual rainfall across most of the region, but some seasonal shift in rainfall, with drier dry seasons, and shorter, more intense wet seasons;
- Sea level is expected to rise by 33 cm by 2050 on top of the observed rise of 20 cm over the last 50 years;
- An increase in the temperature of the sea surface may increase the intensity and incidence of typhoons during El Ninõ years; and
- The impact of glacier melt is negligible in the two main catchments of the GMS (Mekong and Irrawaddy). The situation may differ slightly in the Salween catchment where the contribution of ice melt to total runoff is higher.

**Figure 4**

**Changes to temperatures and rainfall are anticipated across the Greater Mekong Subregion**

Note: Scenarios A2 and B2 derive from Nakicenovic and Swart 2000



A high level of uncertainty surrounds all these projections, with the exception of those forecasting rising temperatures. The rise in $CO_2$ emissions between 2000 and 2007 was higher than that predicted by the worst-case scenario of the Intergovernmental Panel on Climate Change (IPCC) and global warming may accelerate more quickly than current models indicate. Projections of rainfall and runoff are so inconsistent that it is counterproductive to use them to shape adaptation strategies until more reliable estimates are available. A better option is to assume increased variability and uncertainty of water availability, and manage water resources cautiously. Long-term changes will be more severe (see box opposite).

## Impacts of climate change on agriculture

Climate change has impacts on agriculture:

- Directly, at local scale, due to changes in temperature, rainfall and sea-level;
- At local to subnational scales, through changes in water regimes; and
- Indirectly, at global and GMS scales, by physical, social or economic means, such as sea-level rise, migration or changes in food prices.

**Increased temperature:** Warmer conditions can reduce yields of crops and pastures by preventing pollination. For example, rice yields decrease by 10% for every 1 °C increase in minimum temperature during the growing season.

**Increased $CO_2$:** This has a fertilization effect and can increase the yield of some crops (including rice, wheat, grasses and most trees).

**Increased pests and diseases:** Higher temperatures and longer growing seasons could favor damaging pest populations.

**Increased water demand:** Higher temperatures will increase evapotranspiration, raising the water needs of rain-fed and irrigated crops and pastures. Scientists believe demand for irrigation in semi-arid regions of Asia will increase by at least 10% per 1 °C temperature rise. The water needs of livestock will also rise.

**Change in viability of crops:** Changes to temperature and rainfall may require farmers to use new varieties or alter cropping patterns.

**Vertical shifts in ecosystems:** Average annual temperature decreases by about 1 °C for every 100 m of elevation in tropical to subtropical areas. Some vertical shifts in ecosystems are likely as temperatures rise, particularly on the Tibetan Plateau and in the montane regions of Yunnan.

**Changes to seasonal timing:** Shifts in the onset, and end of, the wet season may affect crop yields and irrigation demand (positively or negatively, depending on the crop calendar).

**Extreme climate events:** These are likely to become more frequent.

**Sea-level rise and saltwater intrusion:** Rising sea waters will reduce viable crop areas in the deltas and along coasts; saline intrusion already affects 1.4 Mha in the Mekong Delta. Further rises in sea-level will require adaptation measures to protect crops. In the longer term, if the current situation is maintained, sea-level rise could have catastrophic impacts on deltas and coastal areas.

**Impacts on fisheries:** Climate changes will likely affect the metabolism, growth and distribution of many aquatic organisms, as well as influencing diseases that afflict them. Fisheries are vulnerable to reduced dry-season flows; these could dwindle further as temperatures rise. Changes to wild fish stocks, particularly of marine origin, will affect supplies of fish meal and fish oils that support the aquaculture and livestock industries. However, coastal and delta areas rendered unsuitable for crop production as sea-levels rise may provide new opportunities for aquaculture.

**Changes beyond 2050**

Global studies suggest that the rise in temperature will speed up and become nonlinear, and rainfall will increase. Impacts due to climate change to 2100 are projected to be correspondingly much more severe. Experts anticipate that sea-level rise will accelerate to reach at least one meter above current levels by 2100. This will pose a significant threat to coastal and delta regions of the GMS, and demands consideration when planning for the long-term.

## Adapting agriculture to climate change

Because the rates and timings of climate change are uncertain, it is important to build resilient communities that are able to deal with unforeseen changes. Capacity to adapt to change is very closely linked to socioeconomic factors, such as poverty, diversification of income sources, level of education, and access to infrastructure and technology. Promoting broad-based agricultural development to lift rural communities out of poverty is probably the most effective adaptation strategy available.

At a technical level, there is a large body of knowledge about changes in agricultural systems that could help safeguard production. Farmers have always lived with climate variability and have many coping strategies for droughts and floods that will form the basis for adapting to climate change. Many of these adaptation measures are 'no-regrets' responses, which also provide benefits in terms of production or environmental outcomes, including reducing greenhouse gas emissions to mitigate the impacts of climate change (see Table 1, overleaf).

| Subsector | Response strategy | Adaptation | Mitigation | Environmental impacts or interactions (*Red* = negative; **Black** = positive) |
|---|---|---|---|---|
| Crops | Diversify production systems | ✓ | | Reduce monocultures, improve biodiversity, create more resilient systems |
| | Improve crop varieties | ✓ | | Increase yields, reduce pressure for additional farmland |
| | Intensify agriculture | ✓ | | *Use more water, fertilizers, pesticides and herbicides. Generate higher methane emissions from paddy in the dry season* |
| | Improve rice cultivation | ✓ | ✓ | Use less water, increase yield, lower methane emissions |
| | Introduce biofuels (irrigated/annual crops) | | ✓ | *Extract more water, increase demand for agricultural land, creating competition with food crops* |
| | Introduce biofuels (dryland/perennial crops) | ✓ | ✓ | Increase vegetation cover and carbon storage. *Increase demand for agricultural land, creating competition with food crops* |
| Water | Practice reduced- and zero-tillage farming | ✓ | ✓ | Enhance carbon sequestration, restore soil fertility, rehabilitate degraded land |
| | Expand dry-season irrigation | ✓ | | *Extract more water* |
| | Introduce supplementary wet-season irrigation | ✓ | | *Extract more water but not as much as that used by dry-season irrigation* |
| | Improve efficiency of irrigation | ✓ | | Reduce water use and return flows to natural systems |
| | Introduce multi-use water management | ✓ | | Minimize changes to flow regimes |
| | Use groundwater to irrigate | ✓ | | Reduce pressure on surface water (this may affect surface water resources if highly connected) |
| Forestry/ Agroforestry | Restore degraded forests, revert cropland to forest | ✓ | ✓ | Increase vegetation cover (better erosion control) and carbon storage, increase biodiversity |
| | Practice plantation forestry | ✓ | ✓ | Increase carbon storage and improve erosion control |
| | Integrate perennial crops into cropping systems | ✓ | ✓ | Increase carbon storage and improve erosion control |
| Livestock/ pastures | Introduce intensive forage-based livestock production | ✓ | ✓ | Reduce grazing pressure, reduce methane emissions, increase carbon storage in pastures |
| | Improve pastures | ✓ | ✓ | Reduce grazing pressure, reduce methane emissions, increase carbon storage in pastures |
| Fisheries/ aquaculture | Improve governance and policies of fisheries to protect small-scale fisheries and fishers | ✓ | | Improve sustainability of, and provide more equitable access to, fisheries resources |
| | Integrate fish farming into irrigated agriculture | ✓ | | Improve water productivity |
| | Improve aquaculture in reservoirs | ✓ | | Supplement and reduce pressure on native fisheries |
| | Promote and assist small-scale farmers to comply with Codes of Conduct for good aquaculture practices | ✓ | | Reduce dependence on trash fish from marine capture, improve quality of effluent water |
| | Restore mangroves | ✓ | ✓ | Protect coastal land from storm surges, improve habitats and increase biodiversity |
| | Diversify aquaculture | ✓ | ✓ | Cultivate species lower down the food chain, causing carbon sequestration (as opposed to carbon emissions) |

## Other drivers of change in agriculture

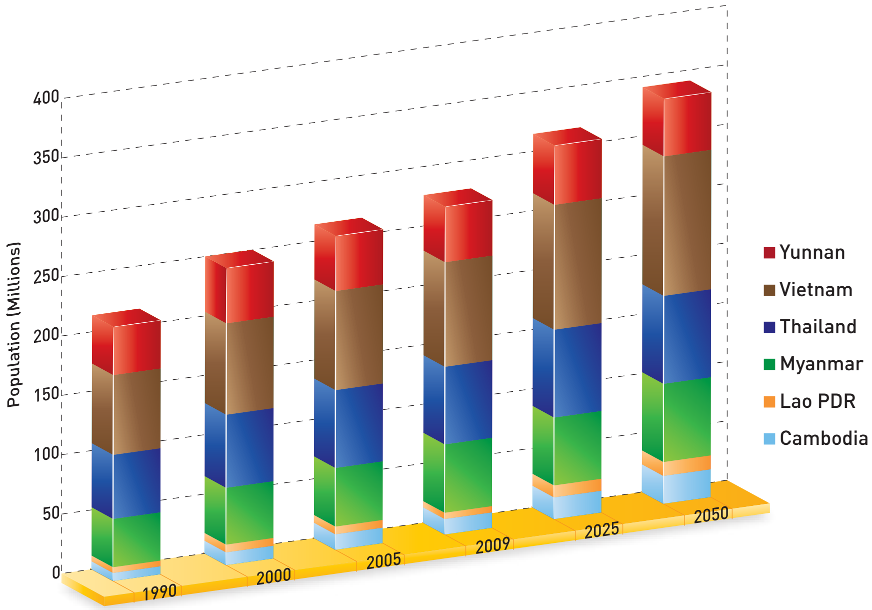
### Rising populations and food security

The current population of the GMS of 275 million is forecast to reach 315 million by 2025 and exceed 340 million by 2050 (see Figure 5). Although levels of nutrition have improved since 1990, undernourishment remains widespread in all countries in the GMS. The 2008 Global Hunger Index considers hunger levels to be 'moderate' in Thailand, 'serious' in Vietnam and Myanmar, and 'alarming' in Lao PDR and Cambodia. Based solely on population growth, food demand will rise by at least 25% by 2050.

**Figure 5**

**Population growth across the GMS**

Source: FAOSTAT, 2009; World Gazetteer, 2009. Note: Yunnan figures calculated from total population for China and apportioned using the Yunnan population from 2009




Food insecurity mostly affects remote mountain areas with low rice production. Local crop failures, lack of access to markets, poverty, floods and droughts can all prevent people getting enough food. Food security is not only a local or national issue, as countries in the GMS are significant exporters. In 2006, Thailand and Vietnam exported more than 12 million tonnes of rice, with much going to food-scarce African nations. Food exports to China are rising as its population swells to 1.45 billion by 2025. A drop in food productivity in the GMS could, therefore, have serious consequences elsewhere.

### Changing diets

As people's incomes rise around the world, they are choosing to eat fewer cereals and more animal products, fish, vegetables, fruit, sugar and edible oils. Global meat consumption tripled between 1967 and 1997. Although the world's population is forecast to rise by at least 25% to 2050, food demand will likely double. A quarter of the projected increase in grain demand is attributed to needing extra livestock feed, prompted by the world's growing appetite for meat.

### Urbanization

Between 20 and 30% of the people of the GMS now live in cities and this trend is expected to increase in the next 20 years. Cities provide alternative sources of income for farmers, and opportunities to diversify; peri-urban areas tend to support intensive horticulture, aquaculture and livestock production. Water quality often declines in peri-urban areas, where farmers must compete with municipal and industrial water users. There are opportunities for reusing urban wastewater in farming, if safety issues are addressed. Conflicts over land can also arise as cities encroach on surrounding farmlands.

**Hydropower development**

All governments in the GMS are considering major hydropower developments to meet growing demands for energy (See Figure 6). Constructing dams will change flow regimes, block the passage of migratory fish and change how sediment is carried and deposited by water. These actions have implications for ecosystem health. Generally, storing water for hydropower development will shift flows from the wet to the dry season and increase fluctuations in water levels. While this could provide opportunities for developing irrigation and avoiding dry-season shortages, it may seriously affect natural fisheries. Recent studies suggest it may not be possible to ensure the free passage of migrating fish, even in dams designed to allow this.

## Figure 6

**Large numbers of dams exist and are planned across the Greater Mekong Subregion**

Source: ADB 2009b; 2009a; Water resources eATLAS; IRN 2009a; IRN 2009b; Irawaddy 2009

## Economic growth and poverty reduction

Although agriculture contributes less to GDP than in the past, it still employs 30 to 40% of the labor force across the region. All countries in the GMS view agriculture as being vital to strategies for expanding their economies and cutting poverty. Studies demonstrate that GDP growth in agriculture benefits the poor proportionately more. However, gaps between rich and poor are widening.

## The global financial crisis

Apart from the Thai economic crisis of 1997–98, national growth rates of 5 to 10% have been commonplace in the GMS for two decades. The economic downturn of 2007–2010 had a severe impact, with all countries in the GMS experiencing a sharp decrease in GDP growth. The downturn will slow or reverse rates of poverty reduction. Loss of employment in manufacturing will likely prompt the return of workers to rural areas, a trend already observed in China. Recovery in the region will be largely determined by China; if it imports more raw materials, agriculture in Southeast Asia could benefit.

## Global trade and China

Global trade is transforming agriculture in the GMS. Demand for exports is increasing production and altering the crops that farmers cultivate, while direct foreign investment is driving commercialization and a rise in large-scale plantations. Trade has long driven agricultural change. The development of rice export markets in Thailand in the 1970s, and Vietnam from the late 1980s, transformed rice production in those countries.

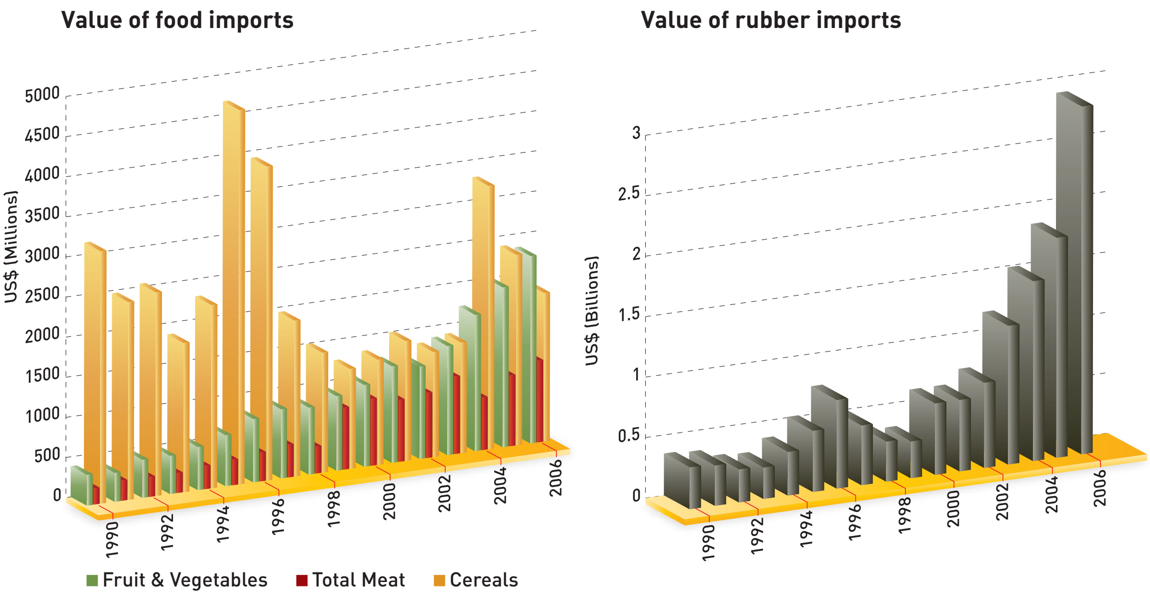
China's emergence in the last decade as a major global economic, trading and manufacturing power has had a profound effect on Southeast Asia. Variations in global food and fuel prices also influence agricultural production in countries in the GMS, in particular in the deltas, lowland plains and coastal zones where food crops and irrigation are dominant.

With a population five times greater than its neighbors in mainland Southeast Asia combined, and an enormous and fast-growing manufacturing economy, China has a seemingly insatiable demand for natural resources including agricultural products. Agricultural imports from all countries in the GMS to China have risen substantially since 2002 (see Figure 7). The volume of agricultural products that China imports from its neighbors, and the value of its investments in plantations will directly shape the agricultural sector of the GMS in future.

## Figure 7

**The changing value (US$) of Chinese imports**

Source: FAOSTAT 2009



**Regulatory pressure**

Environmental lobbies and an increasingly discerning consumer market are putting pressure on food producers to ensure the safety of their wares. For example, more and more importing countries are demanding compliance with Hazard Analysis and Critical Control Points (HACCP) for fish and fisheries products. This is now becoming a major issue for exporters of aquaculture products, such as Thailand and Vietnam. It may well result in more environmentally sound practices but will put added pressure on small producers unless they can get financial assistance to help them comply.

## Rethinking agriculture

Agricultural production in the GMS is steadily increasing. There are now sufficient surpluses to export food, but this benefit has come at a high environmental cost and without considerably reducing rural poverty. To meet future needs, agriculture must be transformed to deliver food security, environmental services (such as clean water and carbon sequestration) and economic growth, in a context of increasing uncertainty on all fronts. Future agricultural systems will need to be flexible and diverse to withstand and respond to climate change and other factors. Nations will need to:

- Secure and increase food production under changing climate and market conditions and the looming water crisis;
- Protect and restore ecosystem functions and services in agricultural landscapes, including those that mitigate greenhouse gas emissions from agricultural sources; and
- Reduce the vulnerability of communities to climate change and other global changes, by improving the capacity of small-scale producers to adapt.

### Securing and increasing food production

Sustainably producing food for the world's growing population must remain the overwhelming priority for agriculture. Three options exist for increasing food supply: increasing productivity from existing farmland; expanding production areas; and reducing postharvest food losses. Building on the technologies of the 'green revolution', which kept India's population from starvation in the 1960s to 1980s, scientists are developing solutions to increase agricultural productivity without the environmental costs often associated with agricultural intensification. If applied appropriately, these solutions could provide very large increases in food production. The following solutions are being introduced, with varying levels of success, across Southeast Asia:

- Intensification (double-cropping, intensive livestock farming, aquaculture)
- Improving crop, livestock and cultured-fish varieties (higher-yielding, drought- and pest-resistant) and matching crops to prevailing conditions
- Improving crop, livestock and fish nutrition (chemical and non-chemical fertilizers, mulching, legume rotations, improved feed formulations)
- Controlling pests and diseases (pesticides, herbicides, biological controls, integrated-pest management)
- Better land management (crop rotations, controlling erosion, conservation farming techniques)
- Irrigation (expanding irrigated areas, increasing efficiency, drip irrigation, supplementing rain-fed crops with irrigation, reusing water, wastewater irrigation)
- Better water management in rain-fed farming (water harvesting, diversified storage, conservation agriculture, multiple-use of water resources for diversified farming)

The majority of high-quality agricultural land in the GMS is already being cultivated, so opportunities to expand operations are limited. The lowland plains in northeast Cambodia and Lao PDR could potentially yield new agricultural land but much of the area has poor soils, access to water is limited and the remaining forests have significant conservation value. A better option may be to reclaim formerly productive lands that have become degraded or been made inaccessible due to conflicts. There are significant opportunities to expand aquaculture production into a range of environments.

Total postharvest food losses (as a result of processing, spoilage, pests, storage and distribution) are very large, estimated at 10 to 40%, though estimates vary widely for different crops and regions.

Cutting postharvest losses could add significantly to food supplies both locally and globally, and reduce intensification and related negative environmental impacts.

## Protecting and restoring ecosystem functions

Agriculture concentrates and enhances ecosystem services, such as those providing food, but this often comes at the cost of other natural functions. Deforestation reduces an ecosystem's ability to regulate erosion, eradicating wetlands prevents streams from regulating floods, and clearing mangroves weakens nature's protection against storms. Agricultural landscapes can be modified to reverse these negative impacts and enhance an ecosystem's ability to function effectively. For example, planting trees prevents soil erosion, artificial wetlands process sewage, and replanting mangroves reduces storm impacts.

The challenge is to create productive agroecosystems that deliver valuable regulating services while sustainably producing food. Mimicking natural systems is one way to achieve this. For example, paddy fields emulate the water retention of natural wetlands. They provide rice and fish, while absorbing floods, recharging groundwater supplies, controlling soil erosion and purifying water. Many traditional agricultural systems exemplify high-functioning agroecosystems.

One ecosystem service that can be enhanced by carefully managing land and water resources is the reduction of greenhouse gases. Agricultural practices have compromised the ability of natural ecosystems to sequester carbon and regulate nutrient fluxes, making farming a major contributor of greenhouse gas emissions in many developing countries. Farming and land management could, therefore, play a major role in mitigation efforts. Adopting mitigation practices will also help nations adapt to climate change and have positive impacts on environments and ecosystem services.

## Improving livelihoods of the rural poor

Improving the livelihoods of small-scale farmers and fishers who constitute the majority of rural producers is key to building resilience in agricultural systems. Rural communities are presently operating within a rapidly changing environment. In this 'new rurality', the global economy is driving change in markets, natural resources are becoming depleted, land tenure/access is insecure, institutions are becoming decentralized, farmers have more opportunities to earn money from urban ventures, and climate change is presenting new risks to production.

As most smallholders have limited capital and assets, they are vulnerable to extreme climatic events and have a high level of food insecurity. Their strategies for coping with change tend to be to diversify, limit costly inputs, such as fertilizer and rely on social networks. At the national level, promoting economic growth remains an effective way to reduce poverty. At local scale, improving rural livelihoods requires efforts to reduce risk, particularly among disadvantaged groups such as women, children and the elderly. Effective actions include:

- Securing tenure for land, water rights, and common property access rights for forests, wetlands, rivers and lakes;
- Diversifying production to spread risk of losses (mixed crops, livestock, aquaculture);
- Easing access to transparent and competitive markets;
- Supplementing agricultural income with off-farm work and by developing enterprises;
- Providing financial safety nets (credit, crop insurance and crop mortgages) to mitigate risk;
- Developing emergency food and nutrition programmes; and
- Planning for disasters to reduce risks from flood, cyclones and drought.

## Using water more productively

Using water efficiently is key to future food security and economic growth in the GMS. Although not obviously water scarce, parts of the region experience difficulties accessing water and face shortages during dry seasons. Increasing demands from agriculture, cities and industry will hinder efforts made to maintain river flow regimes vital for aquatic habitats. Agriculture must produce 'more crop per drop'.

**Improving water management in rain-fed farming**

Rain-fed farming dominates production in the GMS. Much of the wet-season rice crop is either rain-fed or has limited supplementary irrigation. Drought poses a major risk in the plains and uplands, while crops sown in the deltas and on floodplains face failure from floods and droughts. In the Mekong floods of 2000, Cambodia lost around 400,000 ha of rice. Many technologies and practices for improving water management at farm-scale are available, ranging from traditional techniques to modern innovations. These include:

- Conserving soil and water in-situ, by employing conservation agriculture methods (planting pits, infiltration ditches, mulching, contour banks). Conservation farming increases production by reducing the risk of stress from drought. For example, adding bentonite clays to fields in Thailand increased rice yields by 30–100%;
- Harvesting and storing rainwater and runoff (small earth dams, tanks, hand-dug shallow wells) to reduce risk of crop failure. Storage ponds can also be used to cultivate fish, boosting livelihoods and income;
- Technologies for efficiently applying water to plants (clay-pot subsurface irrigation, bucket irrigation, direct application by hose); and
- Planting drought and flood-tolerant varieties to increase yields and reduce crop losses.

**Improving water management in irrigated farming**

Many large- to medium-scale public irrigation schemes are performing below their potential due to inappropriate design, operation and maintenance. Given past and planned investments, improving their performance must be a priority. Options include upgrading distribution systems, adopting drip or pivot irrigation, and producing 'wet-dry' rice, where paddies dry out intermittently instead of being permanently flooded. Intensifying cropping systems by using full and supplementary irrigation during the dry season will help realize the full value of existing irrigation infrastructure.

Existing irrigation systems were designed around rice, which tolerates the inflexible delivery of water. Water delivery now needs to be more flexible to allow farmers to grow a more diverse range of crops. The move away from monoculture farming, coupled with underperforming centralized irrigation schemes, has resulted in millions of farmers extracting groundwater with small pumps, especially in Thailand and Vietnam. Overpumping has already degraded groundwater resources in several regions. A comprehensive assessment of groundwater potential and use in the region is urgently needed.

Irrigation schemes generate return flows, often containing high levels of dissolved salts, pesticides and minerals. There are several innovations that can be used to make this otherwise problematic water, usable. One such innovation is sequential biological concentration, which concentrates salt in the water to a manageable level. Reusing urban wastewater offers a way to increase efficiency of water use as well as reducing costs associated with wastewater treatment plants.

**Managing environmental flows**

Freshwater capture fisheries contribute very significantly to food security and to the economies of countries in the GMS, so maintaining the health of freshwater ecosystems is a priority. The health of rivers and the natural services they provide deteriorate when natural flows of water, sediments and organic materials are disrupted. Hydropower developments and diversions of water for agriculture are both placing pressure on rivers across the GMS. Scientists have developed methods for assessing the minimum flows required to ensure a river's health, even where detailed hydroecological data is not readily available. Such analyses need to be incorporated into water resources planning before extensive developments are undertaken.

**Maintaining good water quality**

High-yielding farming systems depend on synthetic fertilizers, containing nitrogen and phosphorus. A significant amount of applied chemicals ends up in waterways. Excess nitrogen and phosphorus cause: eutrophication, harmful algal blooms and hypoxia; damage wildlife and habitats; affect human health; and contribute to greenhouse gas emissions.

Fewer problems arise when farmers use fertilizers more efficiently. Over the past 25 years the USA has increased its nitrogen efficiency by 36%, by timing applications appropriately for the crop and soil. Other strategies for improving efficiencies are: using specially-developed seed varieties; planting cover crops or reducing tillage to prevent leaching, evaporation and erosion; and closing the nutrient cycle by applying livestock or human wastes. Opportunities exist for farmers to reuse wastewater from cities and wastes from intensive livestock farming.

Nutrient management may take on a new urgency as global supplies of phosphorus run out. Most of the world's farms do not have adequate amounts of phosphate, so demand for phosphate fertilizer is increasing. Scientists estimate that the remaining reserves will last for between 60 and 130 years.

CHU THAI HOANH / IWMI

## Putting plans into action

There are a number of approaches that can be taken to help transform agriculture in the coming decades.

### Actions governments can take include:

- Investing in agricultural infrastructure and rural roads
- Policies (for example, supporting agricultural diversification or promoting exports)
- Making land reforms to improve security of tenure
- Legislation, such as making environmental impact assessments mandatory for major infrastructure or land use changes (such as large land concessions) and following up with environmental audits to ensure mitigating measures are implemented
- Zoning of land use (for example, intensive poultry farming is forbidden around Bangkok)
- Regulations mandating or prohibiting particular practices (for example, Yunnan forbids farming on slopes exceeding 25 degrees)

### Useful financial mechanisms include:

- Tariffs and taxes, such as tariffs on pesticides to discourage unnecessary use
- Subsidies (for example, the Thai Government subsidizies irrigation for sugarcane)
- Access to finance, such as micro-credit
- Contributions in cash or kind for initial costs of adopting new practices (for example, Yunnan's government provided materials and labour to establish terracing for upland rice)
- Incentive payments, such as monies for ecosystem services and benefit sharing (for example, Vietnamese farmers were paid to re-establish forests)
- Trade mechanisms such as quality standards. These include Codes of Conduct for good aquacultural practices, and certification programmes such as the Forest Stewardship Council stamp for sustainable timber
- Market mechanisms and consumer demand, such as for organic produce
- Insurance schemes to decrease risk of adopting new practices

### Promoting awareness is vital and can be achieved by:

- Agricultural extension and advisory services, and demonstration projects for new techniques
- Participatory implementation and farmer-to-farmer education programmes
- Incorporating local knowledge into research findings
- Improving access to information

Demographic, economic and social pressures have driven very rapid changes in farming in the GMS in the past two decades. Climate change is one of many factors influencing agricultural production today; others include rising populations, changing diets, increasing urbanization and global trade. In the next 20 or 30 years, climate change is not likely to be a major driver of change but beyond that, climatic shifts may call for major changes in agriculture. The projected relatively slow pace of climate change to 2050 provides an opportunity to increase the resilience of farming systems. How well nations adapt in this intervening period will likely dictate how they cope with the anticipated extreme climate-related changes forecast for second half of the century, including sea-level rise in the highly productive deltas that currently supply rice and fish to most of the region's people.

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