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Southeast Asia START Regional Center

Assessing the Implications of Climate Change at the Provincial Level: *Krabi, Thailand*

Coastal areas in the Greater Mekong region are particularly vulnerable to the impacts of climate change. To predict how these areas will be affected, their socioeconomic and environmental contexts must also be understood.

Rising sea levels and the clearing of native mangroves for commercial shrimp and salt farms has contributed greatly to the destruction of large tracts of coastal mangroves in Thailand

In early 2008, the WWF Greater Mekong Programme (GMP), with support from WWF's Macroeconomics Programme, collaborated on a pilot study to assess climate change vulnerability and its implications for economic development in coastal areas. Two provinces - Krabi in Thailand, and Ca Mau in Vietnam - were chosen as different examples of coastal geomorphology and economy. These studies were unique in that for the first time they engaged local stakeholders to explore potential impacts on a variety of sectors using regional scale climate models applied at an appropriate local scale.

Krabi Province lies on the west coast of peninsular Thailand, facing the Andaman Sea, and its robust economy relies primarily on agriculture and tourism. Palm oil and rubber, the principal crops, cover 95% of Krabi's cultivated area with many smallholder farms as well as industrial plantations. And, in spite of the December 2004 tsunami, tourism income has recovered and almost doubled since 2002.

Krabi covers 4,710km^2; in 2007 its population was 411,000. Per capita income was $2,800 in 2006. However, not all residents have shared in the agriculture and tourism boom. Inhabitants of small coastal communities continue to depend on harvesting fish and shellfish from Krabi's coastal waters. Some have added family-scale aquaculture as a source of income.

Krabi Province, Thailand

The seas offshore have particularly high biodiversity, including globally endangered marine mammals and sea turtles, abundant mangrove forest, 13.5km^2 of coral reefs and substantial seagrass beds. These resources remain plentiful and well-protected.

Design of the Study

WWF chose Krabi for this study because of its high level of biological diversity existing alongside valuable economic activities such as fisheries, aquaculture, agriculture and tourism. Emphasis was placed on understanding the impacts of climate change on local people's livelihoods, natural resources, and ecosystem services. The Krabi study was carried out by WWF in partnership with the Southeast Asia Regional Center of the Global Change SysTem for Analysis, Research, and Training (START).

The study team assembled data from a number of government sources and mapped it (using GIS) for the province's upland, coastal and urban areas. Future climate scenarios - simulated with the Hadley Centre's PRECIS model - were based on IPCC projections (A2 scenario) of greenhouse gas emissions and incorporated estimates of

Coastal inhabitants depend on harvesting fish and shellfish from the coastal waters

mean sea level rise and tropical storms from the climate model as well as extrapolation of historic and current trends.

The study team reviewed provincial planning documents and interviewed a cross-section of stakeholders in Krabi's upland, coastal and urban zones to gauge their awareness of likely climate change scenarios and their vulnerability. It was evident that many participants were aware of climate change as a global phenomenon, but hardly any had considered local impacts. In the province development plan, there was no mention of adaptation to likely climate change impacts although about 30% of planned projects would be vulnerable to them.

The Modeling Results

Temperature change: modest. The WWF-START PRECIS model estimated that inland temperatures in Krabi Province will rise by slightly more than 1°C over the next 10 and 25 years while, due to the moderating influence of the ocean, coastal temperatures will rise less than 1°C .

Rainfall change: very significant. The annual monsoon will be shortened by two weeks by 2018, and by four weeks by 2033. Total rainfall is projected to be reduced by 10% by the end of the period.

Sea level rise: substantial, with implications for Krabi's extensive mangrove wetlands. The mean level of the sea off Krabi coasts is expected to rise by about 1cm annually over the next 25 years.

Intense tropical storms: fewer. The assessment team believes the declining trend in cyclone frequency over the past 30 years reflects a shift induced by warming of the Andaman Sea and is likely to persist at or below recent levels. However, minor storms may do more damage to coastal infrastructure as sea levels rise.

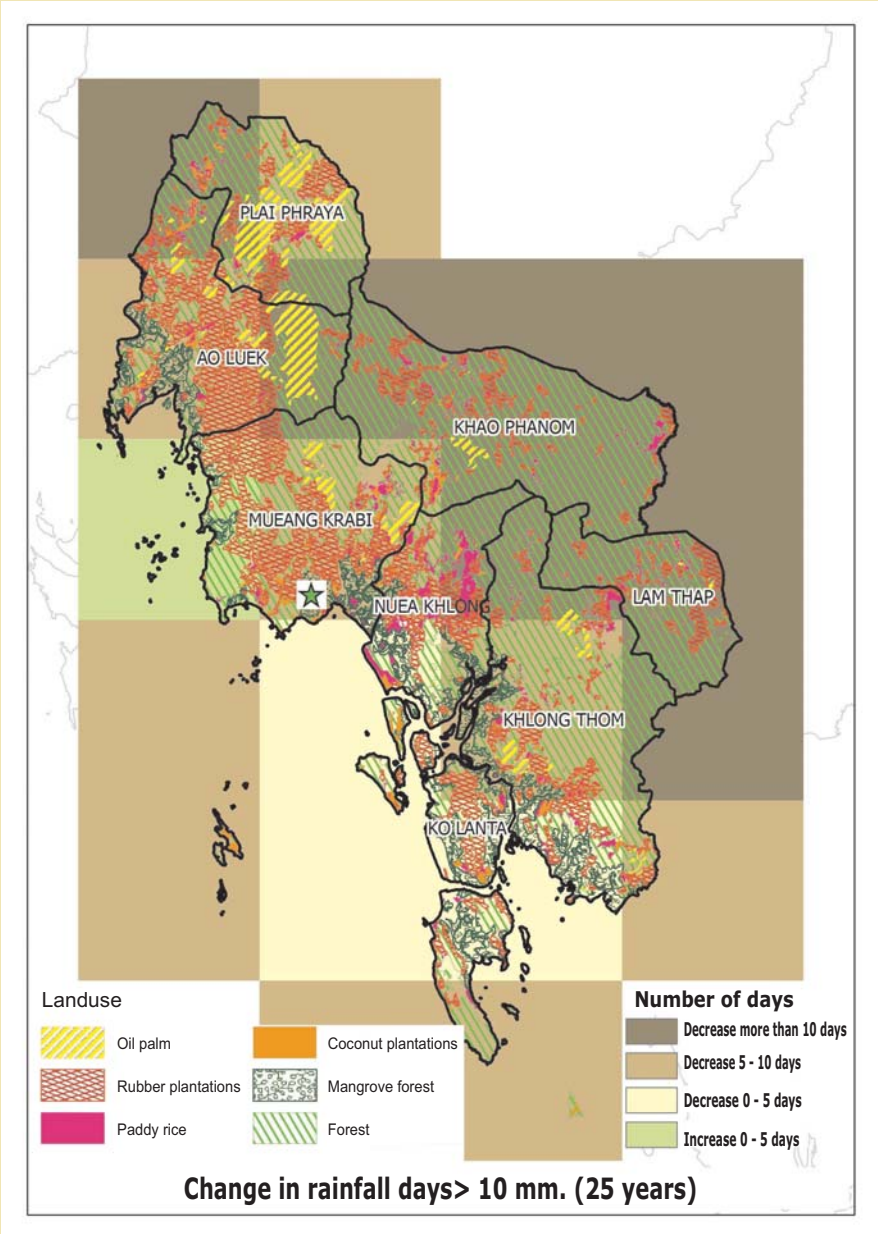
These impacts are only the beginning. The WWF-START PRECIS model projected province-level climate to 2033, a timeframe consistent with provincial development plans. However, evidence is already overwhelming that the effects of climate change will intensify for at least a century to come. Thus the study's results and recommendations will have critical implications for successful socioeconomic and land use planning in Krabi Province, not just for the next 25 years but well beyond.

Impacts and Implications

Fresh water availability. Integrated river basin management for the province's many small rivers and streams will be essential to maintain sufficient supplies of fresh water to all stakeholders, and should be considered in near-term planning. Urbanization, deforestation and land use conversion for agriculture have already put some pressure on natural water sources and stores. If demand for palm oil remains high, producers may resort to irrigation for thirsty trees. Rising sea levels and reduced stream flows will likely increase salt-water intrusion into shallow aquifers in coastal areas.

Healthy coral reefs also buffer storm surges in the Krabi area

Less rainfall implies a longer tourist season, and therefore a higher demand from this sector. Provincial planners should engage stakeholders in a discussion of the province's capacity for tourism growth that takes into account near and long-term climate change impacts; the best strategy may be to cap or slow growth in visitor volume while emphasizing migration to higher value and 'greener' services for tourists.



Coastal ecosystems. The mangrove forests on Krabi's coastline play an important role in buffering against storm surges. They are also spawning grounds for fish and shellfish, a source of food and firewood for subsistence communities, and a contributor to improved water quality. The mangroves typically will 'retreat' inland as water levels rise. Preliminary calculations suggest that Krabi's mangrove forests will retreat an average of 18m on the seaward side if SLR is 50cm. Thus it is critical that roads and other structures on the landward side not be sited close to the current mangrove forest boundaries, to allow room for their inward migration. .

Krabi's 48 **coastal villages** are especially vulnerable to climate change impacts due to their proximity to the sea, fisheries-dependent livelihoods, and limited agricultural land. They are of significant social and cultural value as they are among the last communities in Krabi characterized by a traditional lifestyle. At the stakeholder workshop, several villagers noted that they'd already lost land and asked for assistance in dealing with coastal erosion.

Storms and storm surges. The displacement of historical storm tracks by warming seas suggests that fewer severe storms and attendant storm surges are expected to make landfall in Krabi in the next 25 years. However, Krabi's coastline, as the 2004 tsunami demonstrated, is steadily growing more vulnerable because of tourism development, urbanization and investments in small-scale aquaculture. A 100km/h typhoon passing within 100km could raise sea levels by as much as 2m, eroding beaches and flooding valleys for several km inland. Consequently, planners should zone to avoid urban and industrial development in the lowest-lying areas; plan the relocation of vulnerable populations and infrastructure to less exposed locations; and preserve, restore and rehabilitate coastal and marine habitats wherever possible. "Hard" engineering solutions (e.g., seawalls and levées) outside of urban areas should be avoided because in the longer term they are not likely to be sustainable.

The Krabi seas have particularly high biodiversity, including globally endangered sea turtles

Fisheries. A longer dry season means additional days of fishing and increased pressure on available stocks of fish and shellfish. An agreement by all concerned parties on an equitable, enforceable, and scientifically-based regulatory system to ensure that coastal marine resources are not depleted by either commercial or subsistence fishing must be developed.

Upland areas. Though rainfall will decrease over the next 25 years, it will remain sufficient to meet the needs of rubber cultivation, and the shorter monsoon season will permit additional days of tapping. Productivity per tree is expected to rise by 10-15**%**.

Reduced rainfall may reduce the productivity of oil palms. This provides another incentive to smallholders, already vulnerable to abrupt income swings traceable to market conditions, to diversify their crop base so as to increase resilience to economic and climate changes.

Rising temperatures will most likely force upland ecosystems – in particular Krabi's hill evergreen forests, protected in Khao Phnom Benja National Park – to retreat to higher elevations wherever possible. Research is needed to develop a strategy that protects the high conservation values of these ecosystems.

Urban areas. Urban zones are likely to face water scarcity during the dry season, in response to which basin-wide water management systems will be essential. Engineering for infrastructure, in particular storm and wastewater management, should anticipate increasing climate change impacts over a 100 year horizon.

In summary, this study underlined the major challenges climate change will pose to Krabi Province. Careful planning, based on rigorous science and involving all stakeholders, will be fundamental to ensure sustainable development for the province's people and ecosystems.

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