IMPROVED WATER SECURITY INCREASES ADAPTIVE CAPACITY TO CLIMATE CHANGE

Introduction and background

Climate change policy has been developed and the agenda has focussed mainly on adaptation and mitigation. A central thrust is to find ways that can lessen the impacts of climate change on national growth and people's well-being and to tackle the main cause of climate change through reducing greenhouse gas emissions (e.g., carbon dioxide) from different economic sectors. Cambodia does not contribute significantly to the causes of climate change but it is highly vulnerable to the most direct effects such as irregular rainfall, drought and flooding, which are already having far-reaching consequences for the livelihoods of local people. The most negative impacts are increased flood risk and severe drought, leading to extremes of either too much or too little water for rice cultivation.

This paper examines how climate and human system change has affected the livelihoods of local communities in the Stung Chrey Bak catchment through alteration of water security. It draws on a series of CDRI studies carried out in the area since 2007. These studies used a community participatory research approach through extensive consultation and engagement across different stakeholders involved in catchment water management, including provincial government technical departments, district agencies and local communities.

Stung Chrey Bak catchment

The catchment is located in Kompong Chhnang province. Rice farming practices are changing rapidly from a single rain-fed crop to irrigated double or triple cropping. Seven irrigation schemes—three in the upper, one in the mid- and three in the lower reaches—extract water from the Chrey Bak stream, mainly for dry season cropping (see Figure 1). In the downstream area, where cultivation depends entirely on irrigated dry season farming because of flooding during the wet season, farmers are entirely dependent on dry season stream flow. The rapidly growing demand for irrigation has put intense pressure on local water supplies, raising concern about the equity of water allocation, sustainability of water usage, social friction among water-user communities and long-term sustainability of water resources. Traditional supply-based water planning is clearly no longer appropriate. Instead, irrigation and crop planning needs to focus more on demand-side water management (Chem, Hirsch and Paradis 2011).

Research framework: The effects of climate and human system change on water security

The study framework, depicted in Figure 2, builds on an understanding of the complexity of the links between climate change and water security: the processes that control the interactions between natural systems and human systems at catchment scale shape vulnerability and adaptation capacity and the need for better access to water. This framework's hypothesis is that good water governance plays important roles in increasing the adaptive capacity of the population and institutions through which the impacts of climate and human system change on water security and their implications for local livelihoods and adaptation strategies are identified.

Natural and human system change

Temperature and rainfall will increase. That the risk of flooding and drought adversely affect lives and livelihoods is evident. And localised flash floods are likely to be more severe (Eastham et al. 2008). Flooding is not just caused by rainfall variability, but also by land use change and hydraulic structures such as weirs and spillways that regulate natural water flows. Forest cover loss has increased the rate of soil erosion, and regulated flow regimes have affected downstream water availability. Due to water shortages downstream, competition over water allocation for dry season rice cropping between upstream and downstream irrigation communities

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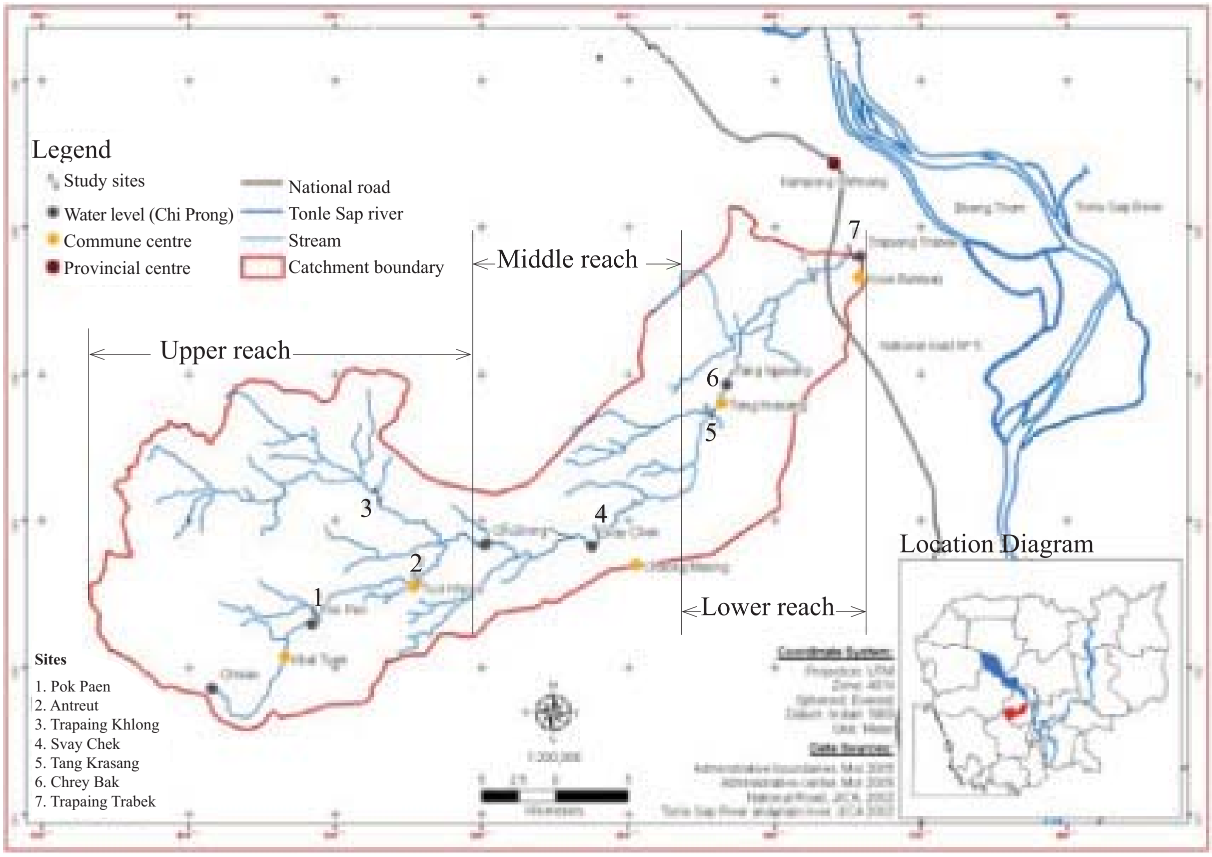
Figure 1: Stung Chrey Bak catchment, Kompong Chhnang province



Source: Chem 2013

has been intense. One of the biggest challenges arising from natural and human system change is a lack of water in the dry season (Chem 2013). The most pressing issue confronting the catchment today is water security.

Water security

Sustainable access to an adequate amount of safe water at an affordable price are key factors in the concept of water security. This study assesses the availability of water in Stung Chrey Bak catchment using modelling tools to measure water "shortage" in relation to water "scarcity". Water shortage is population-driven and is linked to how many people have to share the water. Water scarcity is demand-driven and the focus falls on how much water is withdrawn.

By definition, water security takes into account access and affordability of water as well as human needs and ecological health (Cook and Bakker 2012). It covers the broad range of accessibility, food security and human development. Achieving water security therefore needs (1) modelling tools to measure water availability and quality, and (2) sound water governance that ensures accessibility, equity of access and sustainable water use.

Water security also focuses on water-related hazards such as contamination, flood, drought and infrastructure development. Concerned with protecting water systems against water-related hazards and safeguarding access to water functions and services, water security involves the prevention and assessment of water contamination and the protection of vulnerable water systems.

Vulnerability to coupled natural-human system change

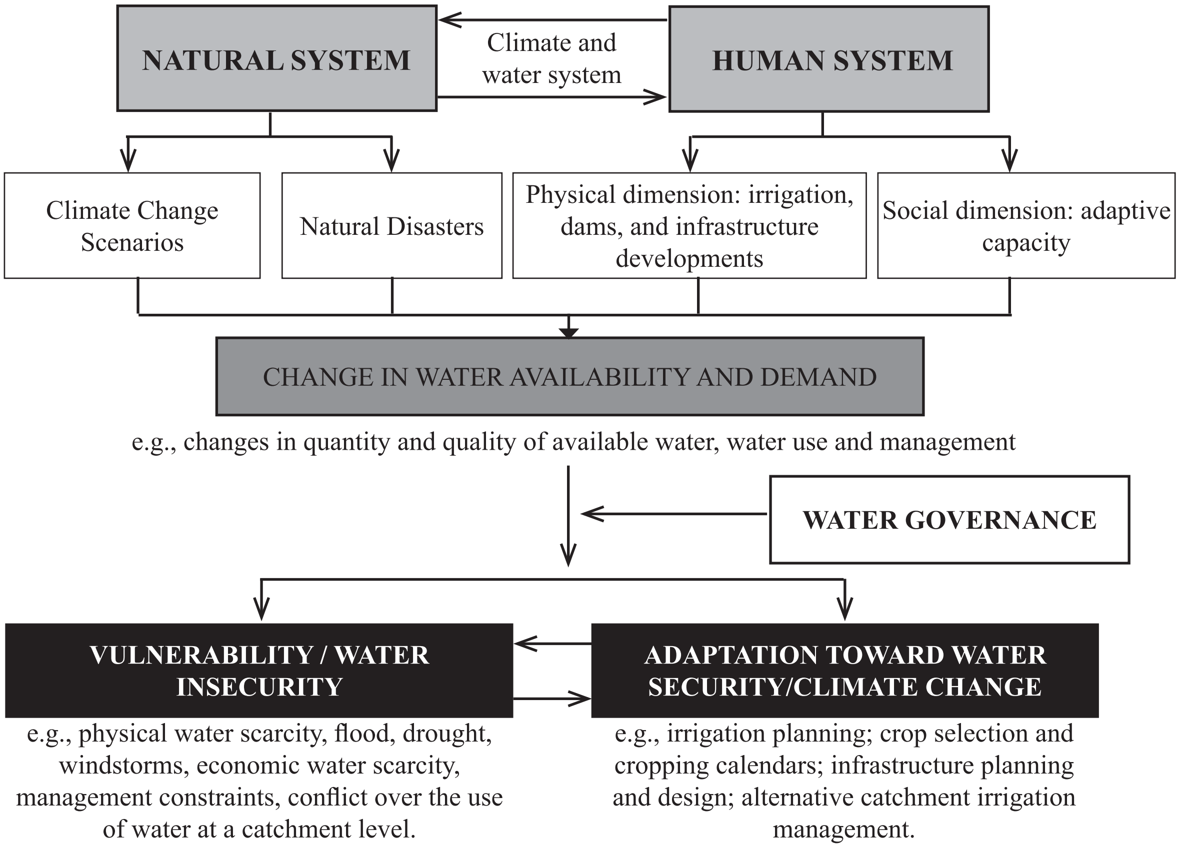
The concept of climate change considers that vulnerability to climate change is a function of three components: exposure, sensitivity and adaptive capacity. The study applies these terms as defined by the Intergovernmental Panel on Climate Change (IPCC 2001).[1]

Exposure: "The nature and degree to which a system is exposed to significant climatic variations" (p. 987).

Sensitivity: "The degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. The effect may be direct

1 In the following definitions, "system" refers to both human and natural systems.

Figure 2: Conceptual framework for the impacts of natural and human system change on water security



Source: CDRI 2012

(e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise)" (p. 993).

Adaptive capacity: "The ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences" (p. 982).

Results and discussion

Exposure

Stung Chrey Bak catchment is divided into three distinct geographic areas: upstream, middle-reach and downstream. Exposure to the effects of climate change varies accordingly. Communities in upper and middle-reaches are exposed to the risk of flash floods whereas those in downstream areas are exposed to seasonal flooding from the Tonle Sap River. All three areas are affected by drought.

A study of rainfall change in Kompong Chhnang province by the Learning Institute found that rainfall patterns in the early 20th century were characterised by peaks in September. By the late 20th century the peaks had shifted to October. Since then, monthly rainfall during the dry season has been declining, especially in the months of January, February, November and December (Ham and Someth forthcoming).

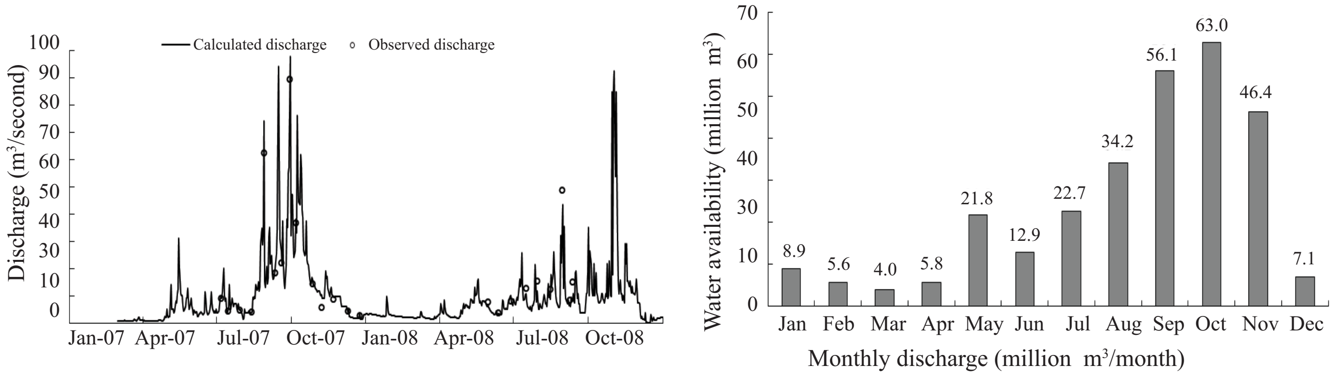
Chem (2013) used observed stream level data to calculate stream flow using a rating curve. Stream discharge was calculated and compared with observed data. It was found that the peak discharges of the Stung Chrey Bak stream occur in October, similar to the findings of the Learning Institute's study.

In addition to climate variability, human activities have also caused changes in catchment land cover. Agricultural intensification, irrigation development and urbanisation have increased water demand. Forest loss has increased soil erosion, reservoir sedimentation and travel time of flood, making the area more prone to flash floods. The population in Stung Chrey Bak catchment faces both water shortages and water scarcity problems.

Sensitivity

Upstream communities cultivate only wet season rice. Middle-reach communities grow mostly wet and some dry season rice crops (Tang Krasang irrigation

Figure 3: Stung Chrey Bak stream discharges, 2007-08



Source: Chem 2013

scheme). Downstream communities cultivate mostly dry season rice. Agricultural intensification driven by population growth and concomitant increase in demand for food has encouraged farmers to expand the command areas for dry season cultivation. Before 1990 there was no dry season rice cultivation in this catchment at all but dry season cropping has since increased significantly. The total rice planted area covers more than ten thousand hectares (10,370 ha), and 740 hectares is used for dry season cropping. We estimated that the cropping area has been expanding at a yearly rate of around 5 percent since 1992, especially in the downstream floodplains where richly fertile soils support high yields. This trend has increased the demand for irrigation water in the catchment yet institutional arrangements for demand management have not kept pace. Consequently, water allocation has not yet been properly planned and all available water is commonly used to support irrigated cultivation in the dry season without considering environmental flow requirements.

Ecosystem services especially capture fisheries are being degraded or used unsustainably. High erosion and therefore increased sediment yield has been filling up the reservoir, resulting in an annual loss of water storage capacity. The lowest flow of 4 million cubic metres is in March. Water scarcity is most acute in this period and coincides with peak irrigation demand. The resultant pressures lead to severe crop damage and intense conflict over water use.

Water shortage in the forms of economic[2] and physical[3] water scarcities is the major constraint in the dry season (Figure 3). Monsoon rains provide abundant water in September and October but farmers face meteorological drought (low rainfall) in June or July. Farmers in the upper and middle reaches need supplementary water from the irrigation scheme during this period.

Hydrological and meteorological droughts have severely affected dry season rice production in this catchment. In a hydrological drought year farmers in Trapeang Trabek (scheme 7 on Figure 1) can start cultivation earlier in early November, though this irrigation scheme has faced severe water shortage in February and March. In contrast, during a wet year, because peak discharge occurs in October, farmers in this scheme have to plant their crops later (in late November) and have few water shortage problems in February and March. This emphasises the importance of hydrological and weather forecasting for crop planning in this catchment.

Adaptive capacity

Water is the key input for subsistence farmers. Those living in the lowlands know how to manage their irrigation water use; they can access irrigation services and have gained experience in coping with drought. However, water management coordination between upstream and downstream irrigation schemes in the catchment remains a great challenge for irrigation managers and farmer water user communities (FWUCs). To help cope with flooding, the Committee for Disaster Management (CDM) is in place at all four administrative levels—national, province, district, commune and village.

2 Economic water scarcity refers to a lack of water caused by a lack of financial investment in water infrastructure to extract water for use.

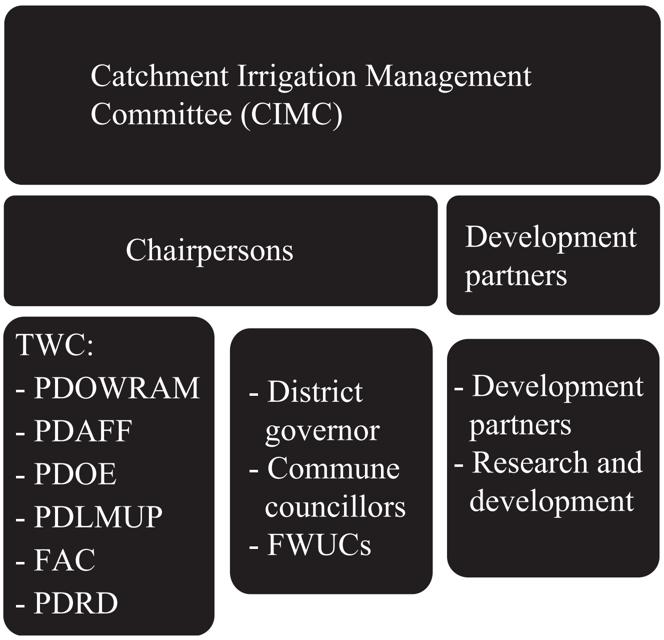
3 Physical water scarcity refers to a lack of water in the stream.

The Provincial Department of Water Resources and Meteorology also plays very important roles in managing flood and drought. These subnational entities have an emergency disaster preparedness plan, but low capacity and limited financial resources impede them from responding sufficiently or quickly enough to the growing urgency to adapt to climate change. This poor response is evident in local communities' weak adaptive capacities and their limited knowledge about climate change adaptation options.

Conclusion: Present and future challenges

Stung Chrey Bak catchment is highly *exposed* to drought, more so than to flood. Drought has become an almost yearly problem. Most rice producers have suffered crop damage and low yields. The frequency of such hazards has steadily increased. Livelihood resources such as water, land, forest and fish are highly *sensitive* to the effects of both human and natural system change, and the *adaptive capacity* of the population to climate change is low.

Figure 4: Possible catchment management agencies to be involved in a CIMC



Note: FAC=Fishery Administration; PDAFF=Provincial Department of Agriculture, Forestry and Fisheries; PDLMUP=Provincial Department of Land Management and Urban Planning; PDOE=Provincial Department of Environment; PDOWRAM=Provincial Department of Water Resources and Meteorology; PDRD=Provincial Department of Rural Development; TWC=Technical Working Committee.

Source: Chem 2013

Upstream communes have experienced flash flooding while those downstream near the Tonle Sap Lake floodplains have been affected mostly by river floods. Although many people reported exposure to drought, only a few of them understood that drought occurs partly because of climate change or that environmental degradation can lead to flooding. Local communities' knowledge about the impacts of climate change is still limited.

Water shortage and scarcity are the major causes of low paddy productivity and limited production. Ricelands established in upstream areas (especially in Tang Krasang) have moderately few water supply difficulties. But large areas downstream (Chrey Bak and Trapain Trabek irrigation schemes) face genuine water shortages.

Dams, other hydraulic structures and canals assume crucial roles in storing water, regulating flows and conveying water from the reservoir to farmland. Even so, the irrigation system in Stung Chrey Bak catchment is insubstantial. Besides infrastructure, catchment water governance plays an important role in the supply of water to the communities that need it—from storage and conveyance that makes best use of infrastructure and financial resources, to fair water allocation and sustainable water use. However, water governance in Stung Chrey Bak catchment is weak: it has so far failed to facilitate collective decision-making and it has not recognised the different consequences of human and natural system change for water resources management.

The absence of a Catchment Irrigation Management Committee (CIMC) to govern irrigation water appropriation and use creates discontinuities in irrigation water management and therefore uneven water allocation between the seven irrigation schemes. This has led to increasingly tense competition for water between middle-reach and downstream water-user groups. In this case, the primary role of a CIMC would be to establish fixed rules so that irrigation water is distributed proportionally across all seven irrigation schemes thereby optimising spatial water use between upstream and downstream communities.

Recommendations

A better understanding of the catchment's hydrology would enable local water managers to improve irrigation water management and planning. Interviews with farmers and FWUC members revealed a pressing need to create a CIMC and move beyond the current individual focus of irrigation management.

A CIMC will not have the capacity to carry out its function of coordinating planning without the full participation of all catchment water management agencies (see Figure 4). For that to happen, these agencies must have up-to-date hydrological information to understand fully the imperative of joint water and crop planning.

Limited collection of irrigation service fees for operations and maintenance remains a major worry for FWUCs. The suggested CIMC will improve coordination, ensuring that each irrigation scheme receives the right amount of water at the right time. In turn, better access to a more reliable water supply will encourage farmers to pay the irrigation service fee.

The proposed CIMC will coordinate and facilitate the collection and sharing of hydrological data and information to support water allocation decision-making and the harmonisation of crop planning between upstream and downstream irrigation schemes. Further, irrigation systems could provide more benefits if a high level of coordination in crop planning and water allocation between FWUCs, community councils and district officials is achieved. With reliable information on spatial and temporal water distribution, the CIMC could ensure that both upstream and downstream farmers have equitable access to water, especially when water supplies are limited.

Dry season cropping should be planned using hydrological information. Extremely low flows in March (4 million m^3) cause serious water shortages downstream for Tang Krasang, Chrey Bak and Trapeang Trabek irrigation schemes. Highly coordinated efforts for these schemes are required to accommodate existing and anticipated irrigation demand in line with water availability. Cropping patterns should be adjusted year by year in line with rainfall (amount and timing) upstream and Tonle Sap flood (big or small) downstream. Cropping calendars should be planned using hydrological information. Importantly, the dry season cropping areas of the three schemes should not exceed 740 hectares in total, otherwise they risk facing serious water shortages and crop damage.

References

CDRI, Cambodia Development Resource Institute. 2012. "Climate Change and Water Governance in Cambodia." *Cambodia Development Review* 16(4): 1-5.

Chem Phalla, Philip Hirsch and Someth Paradis. 2011. *Hydrological Analysis in Support of Irrigation Management: A Case Study of Stung Chrey Bak Catchment, Cambodia*. Working Paper Series No. 59. Phnom Penh: CDRI.

Chem Phalla. 2013. *Integrated Catchment Management and Irrigation Development: The Role of Hydrological Analysis in Improved Water Governance in Cambodia*, School of Geoscience, Faculty of Science, University of Sydney, Sun Heang Printing House, Cambodia.

Cook, Christina, and Karen Bakker. 2012. "Water Security: Debating an Emerging Paradigm." *Global Environmental Change* 22:8.

Eastham, Judy, Freddie Mpelasoka, Mohammed Mainuddin, Catherine Ticehurst, Peter Dyce, Geoff Hodgson, Riasat Ali and Mac Kirby. 2008. "Mekong River Basin Water Resources Assessment: Impacts of Climate Change." In *Water for a Healthy Country Flagship Report*, edited by CSIRO: Water for a Healthy Country National Research Flagship.

Ham K. and Someth P. Forthcoming. "Impacts of Social-Ecological Change on Farming Practices in the Stung Chreybak Catchment, Kampong Chhnang, Cambodia." In *Learning for Resilience: Insights from Cambodia's Rural Communities*, edited by J.-C. Diepart. Phnom Penh: The Learning Institute.

IPCC, Intergovernmental Panel on Climate Change. 2001. "Climate Change 2001: Impacts, Adaptation and Vulnerability." In *Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.