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ORIGINAL ARTICLE

Sewing climate-resilient seeds: implementing climate change adaptation best practices in rural Cambodia

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Abstract Multilateral support through programs like the Least Developed Countries Fund (LDCF) targets countries widely considered to be the most vulnerable to climate change. Cambodia is one of the six Asian LDCF recipients and with UNDP support is implementing the first adaptation project to arise from its National Adaptation Program of Action. Drawing on primary research conducted in August 2010 through interviews with key stakeholders, this article investigates the project for the likely benefits and challenges it will face in promoting institutional, infrastructural, and community resilience to climate change impacts. We find that the country's ongoing decentralization reforms offer an effective opportunity to mainstream climate change planning into sub-national government operations, but that competing priorities for immediate investment in education, roads, and healthcare may prevent government officers from sustaining a focus on preventative adaptation measures. We conclude that through careful planning, water resources infrastructure and agricultural practices can be designed to withstand climate variability and avoid the need to replace or rehabilitate systems whose specifications were prematurely determined by international donors.

Keywords Cambodia · Climate change adaptation · Development aid · UNDP · Water resources management

1 Introduction

Adaptive capacity to climate change has long been interpreted as a composite of economic, financial, and technological factors. Increasingly, scholars now view human capital and institutional structures as additional determinants (Adger et al. 2007). As a result of deficits in these factors, and compounded by geophysical characteristics like low-lying floodplains, least developed countries (LDCs) are often considered the most vulnerable to climate

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change because they lack adequate resources to plan and implement adaptation actions (Huq et al. 2003). High rates of poverty exacerbate vulnerability, especially for poor populations residing on marginalized lands with higher susceptibility to disasters (Pettengell 2010). Among such countries, the debate on mitigation versus adaptation obligations is clear-cut given low historical and current per capita emissions and their heightened vulnerability vis-a-vis developed countries (Jerneck and Olsson 2010).

In virtue of their sensitivity to climate change, LDCs have been the target of increased multilateral support, through financing vehicles such as the Least Developed Countries Fund (LDCF) which provides grants to accelerate adaptation actions. The Global Environment Facility (GEF) manages the LDCF which was established in 2001 at the United Nations Framework Convention on Climate Change's (UNFCCC) COP7 meeting in Marrakech. One of the Fund's initial mandates was to provide financial support for LDCs to develop National Adaptation Programs of Action (NAPAs) (Ayers et al. 2010). Every LDC signatory to the UNFCCC is eligible to access the Fund which as of June 2010 had garnered $224 million in voluntary pledges, making it one of the largest sources of adaptation finance in the world (ADB 2009; GEF 2010).

Cambodia was first designated an LDC in 1997 (Lum 2007), though Prime Minister Hun Sen announced in early 2006 an ambition of achieving LDC graduation by 2020 (Royal Embassy of Cambodia 2006). Like other LDCF recipients, Cambodia is now beginning to develop government-wide policies to address both immediate and long-term climate change needs. Various multilateral and bilateral agencies have also initiated climate change programming in conjunction with government departments and local partners. With the mobilization of new donor-driven finance, Cambodia anticipates an upsurge of inflows to support adaptation and climate-sensitive development. Their participation in the World Bank's Pilot Program for Climate Resilience is one such example, with $1.5 million of seed funding already allocated towards integrating climate risks into policy and promoting climate-sensitive capacity-building (RGC 2010). Climate finance, where additional to existing aid commitments, marks another source of official development assistance (ODA) which in 2008 exceeded $740 million across all aid types for Cambodia, registering it as one of the most aid-reliant countries in Asia (Table 1). Some sectors are almost entirely dependent on external funding sources, such as water resources where external donors

Table 1 Key development metrics for ASEAN countries

	GDP per capita, PPP (2005 international $) (2007)[a]	Net ODA received (% of GNI) (2008)[a]	Agricultural population (% of total) (2010)[b]
Brunei Darussalam	$47,949	0.0	0.2
Cambodia	$1,717	7.5	65.9
Indonesia	$3,521	0.2	37.3
Lao PDR	$1,861	9.4	74.9
Malaysia	$12,752	0.1	12.0
Myanmar	N/A	N/A	67.1
Philippines	$3,182	0.0	33.6
Singapore	$49,739	0.0	0.1
Thailand	$7,333	−0.2	41.1
Vietnam	$2,455	2.9	63.2

Source: (a) (World Bank 2010); (b) (FAO 2010)

support more than 85% of the allocations to high priority, ongoing, and committed projects (Ministry of Environment 2005).

This paper investigates the first LDCF-funded project in Cambodia, the four-year "Promoting Climate Resilient Water Management and Agricultural Practices in Rural Cambodia" scheme the United Nations Development Program (UNDP) is implementing in Choam Khsan and Chit Borei districts. The article first summarizes the methods of data collection utilized before discussing Cambodia's institutional capacity to respond to climate change. The article then identifies Cambodia's key vulnerabilities to climate change as determined by government analysis and stakeholders that participated in our research interviews. The article next provides a background to the aims and objectives of the UNDP project, which is situated in the context of ongoing decentralization reforms. Since the project only recently began implementation, the final sections of the paper highlight anticipated benefits and challenges of its implementation, based on a synthesis of data collected from interviews with involved stakeholders and our review of climate change literature for the country. We specifically focus on how the project contributes to improving institutional, infrastructural, and community resilience to climate change within Cambodia.

2 Research methods

Climate change adaptation in Cambodia has only recently become a significant policy issue both within and outside government, but a significant number of reports and analyses either country-specific or regional already have been produced (e.g., Eastham et al. 2008; Hoanh et al. 2003; Snidvongs et al. 2003). We reviewed the academic literature, but peer-reviewed studies on the anticipated climate change effects for Cambodia are limited. Inter-ministerial policy and strategy papers like the National Adaptation Program of Action and the Initial National Communication were therefore elemental in improving our understanding of the evolution of the country's climate change landscape.

These documents and the Cambodia-specific grey literature formed the starting point for this research, which was anchored by primary research conducted in August 2010. We conducted in-country face to face interviews with individual stakeholders from governmental and non-governmental organizations engaged in climate change-related activities in general, and the UNDP project in particular, as seen in Table 2. These interviews were conducted in English and semi-structured, leaving scope for asking broad questions about climate change adaptation in Cambodia, common across all interviewees, as well as open-ended questions better targeted to the expertise and position of the respondent. Interviews were recorded when participants gave their consent and were conducted with real-time simultaneous translation into local languages and dialects to minimize potential communication problems related to spoken English. We had limited control over sample bias since the Department of Agriculture organizes focus group discussions and village interviews. As a result, we cannot claim internal or external validity from our findings, which we accept since our interest is in obtaining feedback about the project and its objectives from future beneficiaries. We also attended a UNDP-organized Community Learning Forum on "Climate Change and its Impacts on Agriculture and Water Resources," as seen in Fig. 1. More than 70 local villagers participated and heard presentations from provincial government representatives about potential climate change impacts to their livelihoods. The Q&A session offered an opportunity to observe villagers' awareness of climate change and their receptiveness to ideas introduced by government and UNDP representatives.

Table 2 List of research interview participants

Interview/focus group discussion participant	Location
Preah Vihear Department of Agriculture	Tbeng Meanchey, Preah Vihear Province
United Nations Development Programme Cambodia	Tbeng Meanchey, Preah Vihear Province
Krao Bao Village Focus Group Discussion	Kulen Etbong Commune, Kulen District, Preah Vihear Province
UNDP Community Forum Visit	Preah Klaing Commune, Tbeng Meanchey District, Preah Vihear Province
Sethakich Village Focus Group Discussion	Chhean Mok Commune, Tbeng Meanchey District, Preah Vihear Province
Thanal Bek Village Focus Group Discussion	Thmey Commune, Tbeng Meanchey District, Preah Vihear Province
Development and Partnership in Action	Kampong Thom
Chambak Village Focus Group Discussion	Taing Krasang Commune, Santuk District, Kampong Thom Province
Ministry of Environment	Phnom Penh
General Directorate of Agriculture	Phnom Penh
United Nations Development Programme Cambodia	Phnom Penh
Cambodian Centre for Study and Development in Agriculture	Phnom Penh

One advantage of our research interview approach was the ability to get rich, context specific data on a variety of factors affecting climate change policy in Cambodia in general, and adaptation projects in specific. Another advantage was the input sought from a range of stakeholders in a variety of sectors. One shortcoming, however, was the limited sample size of our pool of experts interviewed. Moreover, while the data gleaned from the interviews was "thick" it was also hard, and time-intensive, to code into meaningful and relevant quotes that we use to supplement our discussion below.

For these reasons, our interviews were supplemented by meetings with prospective beneficiaries of the project. The provincial Department of Agriculture arranged in advance for residents from three communes in Kulen and Tbeng Meanchey districts to participate in focus group discussions (FGD) that were also semi-structured and supported by real-time Khmer translation. An additional FGD was held with members of the Taing Krasang

Fig. 1 Community learning forum held in Preah Klaing Commune, Preah Vihear Province

Commune in Kampong Thom province, a community fishery where Oxfam GB sponsors a women's microfinance program and residents are engaged in both fishing and rice and vegetable farming. Villagers attending the FGDs were not selected by random sampling and therefore their insights are not necessarily representative of the experiences of all villagers in the project's coverage area. Despite this, their input offered a diversity of views on the challenges anticipated with climate change and the implementation of adaptation actions.

3 Resilience and Cambodian institutional capacity

The concept of resilience has emerged to be a central feature in discussions about how developing countries ought to manage climate-related risks. Simply put, resilience is about reducing the vulnerabilities associated with climate change. Adger (1999) argues that social vulnerability to climate change refers to the "exposure of groups or individuals to stress as a result of the impacts of climate change and related climate extremes." He suggests that vulnerability can be disaggregated into individual vulnerability, lack of access to resources, and declining social status of individuals within a community.

"Resilience" therefore refers to a system's capacity to withstand disturbance and still maintain its function and control (Margulis et al. 2008). Young (2010) notes that it can include robustness, the ability to cope with stresses without adapting, or the capacity to deal with stresses through adjustments that stop negative change. Ecosystem resilience generally entails handling stresses in an adaptive manner, adapting to exogenous pressures, whereas engineering resilience utilizes the concept of equilibrium to determine how far a system can be displaced from the fixed equilibrium and still return to it once disturbance has passed (Venema and Cisse 2004; United Nations Development Program, United Nations Environment Program et al. 2008; Marshall 2010). McGray (2009), for example, investigated 135 case studies of adaptation efforts in developing countries and found that some current approaches were problematic and focused only on creating response mechanisms and policies to specific impacts. This strategy presumes such impacts are known, rather than comprehensively reducing vulnerability by improving the capacity to handle *unplanned* and *uncertain* events. They noted three types of adaptive efforts were most useful:

- Building responsive capacity, such as improving communication between institutions, or enhancing the mapping or weather monitoring capability of a government institution;
- Managing climate risks, such as disaster planning, researching drought-resistant crops, or climate proofing infrastructure;
- Confronting climate change, such as relocating communities or repositioning infrastructure in response to flooding or glacial melting.

Similarly, the Economics of Climate Adaptation Working Group (2009), an interdisciplinary expert group from the GEF, insurance agencies, consulting firms, civil society, and academia, examined the costs and benefits of adaptation in China, Guyana, India, Mali, Samoa, Tanzania, United Kingdom, and the United States. Their study found that many adaptation efforts generate net benefits, meaning they not only improve resilience against climate change, but also foster economic development.

For these reasons, developing countries like Cambodia have long considered climate change a serious issue. Cambodia ratified the UNFCCC in 1995 as a non-Annex I member and is therefore obliged to submit periodic reports to the Convention detailing its implementation status. In compliance with those obligations, the Ministry of Environment completed the

country's Initial National Communication (INC) which featured a national GHG inventory, GHG projections and mitigation strategy, a vulnerability and adaptation (V&A) assessment, and an overview of how national laws and policies are integrating Convention commitments (Ministry of Environment 2002). Cambodia acceded to the Kyoto Protocol the same year.

The INC was followed by a National Adaptation Program of Action to Climate Change (NAPA) "to provide a framework to guide the coordination and implementation of adaptation initiatives through a participatory approach and to build synergies with other relevant environmental and development programs," submitted to the UNFCCC in 2006 and developed with support from the UNDP (RGC 2006). The NAPA identified high priority adaptation projects based on the needs raised by stakeholder interviews in 17 provinces and municipalities. A total of 39 projects were proposed with an estimated total cost of $196 million. Preparation for the Second National Communication began in 2007 and its submission to the UNFCCC is expected by mid-2011.

Early climate change work was conducted under the auspice of the Ministry of Environment (MOE) which in 2003 established a subsidiary Cambodian Climate Change Office (CCCO) as the apex body over all climate change-related activities. Three years later, MOE established the National Climate Change Committee (NCCC) as an inter-ministerial body that would coordinate national climate change policy. Each of the participating ministries has a functional unit tasked with climate change-related work, though most involvement occurs at the provincial level. In 2009, the CCCO was promoted to a Department (CCCD) to reflect the increasing number of activities it presides over.

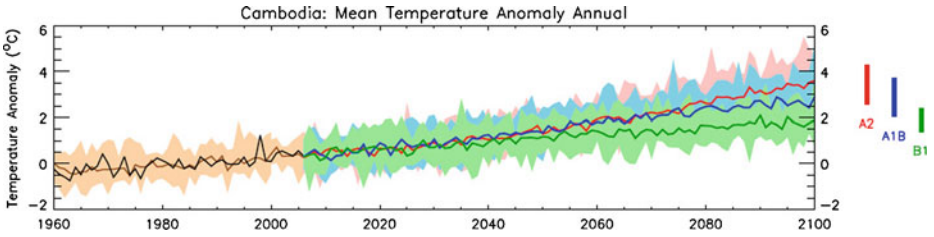
The Cambodia Climate Change Alliance (CCCA), launched in February 2010, convenes government agencies, bilateral and multilateral donors, and NGOs (Scheuer 2010) and is housed under the NCCC. The CCCA serves three main functions: supporting capacity development, conducting outreach and advocacy, and monitoring the implementation of the country's climate change strategy. Through the Climate Change Trust Fund, the European Union, UNDP, SIDA, and DANIDA have donated $8.9 million to support the Alliance's governmental capacity-building work (UNDP 2010b).

4 Cambodia's vulnerability to climate change

4.1 Key sectors

The country's first vulnerability assessment was conducted for the Initial National Communication and determined the most vulnerable sectors to be agriculture, forestry, human health, and coastal zones. To identify the potential impacts climate change would have on these sectors, analysts ran the CCSR and CSIRO general circulation models (GCM) using A2 and B1 SRES scenarios. Model output suggests rainfall trajectories of 0–15% over baseline levels by 2025, and even higher values for 2050 and 2100, though accompanied by broader variation among GCM and scenario outputs (Ministry of Environment 2002). IPCC results for the Southeast Asian region are more muted with little deviation in seasonal precipitation totals through 2039, but with more significant temperature and rainfall anomalies in the latter part of the century (Cruz et al. 2007). McSweeney et al. (2008) find a gradual warming trend through the 2090s, as seen in Fig. 2, and an expected reduction in the number of 'cold' days and nights in any given year. Figure 3 shows a map of Cambodia and the specific vulnerability of communities in the central and northwest part of the country to flooding and changes in rainfall.

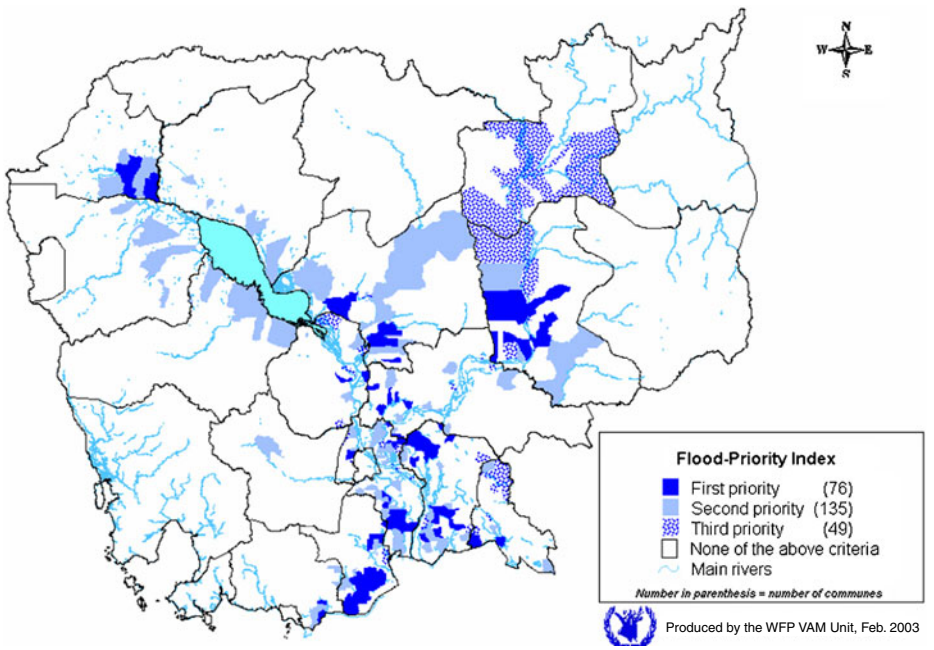
Other impact assessments have been conducted with a regional focus, addressing the Greater Mekong Subregion (GMS) (includes parts of Cambodia, China, Laos, Myanmar,



Source: (McSweeney, New et al. 2008)

Fig. 2 Projected annual mean temperature anomaly for Cambodia

Thailand, and Vietnam) or the Lower Mekong Basin (LMB) (includes parts of Cambodia, Laos, Thailand, and Vietnam). Johnston et al. (2010) use the PRECIS model with ECHAM4 GCM output and predict no significant change in annual rainfall for GMS countries as a whole. They also project decadal temperature changes of about 2.3°C. This is significantly greater than Eastham et al. (2008) who initially tested output from 24 GCMs and then selected the 11 models best able to recreate historical temperature and precipitation data. They forecast a change of +0.7–0.8°C in mean temperature in 2030 for most of Cambodia, with slight reductions in dry season precipitation and larger gains in wet season precipitation (+100–200 mm) for the same year. Another PRECIS model simulation adopted a 1980s baseline and projects +1–2°C increases in minimum and maximum



Source: Royal Government of Cambodia and World Food Program 2003.

Fig. 3 Map of Cambodian vulnerability to flooding and climate related hazards

temperatures across the Mekong Basin by the 2040s. Model output suggests an increase in rainfall of 4% over the same period (Västilä et al. 2010).

Though the country is less exposed to natural disasters than neighboring countries like the Philippines or Indonesia, Cambodia's adaptive capacity is restricted nonetheless by its lower socio-economic, technological, and infrastructural resources (Yusuf and Francisco 2009). Additionally, its overwhelmingly agricultural population and unique geophysical characteristics also negatively impact its vulnerability. Located in the Lower Mekong Subregion, annual monsoon floods inundate the country's floodplains and contribute to agricultural and fishery productivity (Keskinen et al. 2007). During this season, the Tonle Sap Lake, which is connected to the Mekong River via the Tonle Sap River, expands from a dry season area of 2,500 km^2 to 15,000 km^2 and deepens from less than 1 m to 6–9 m (Kummu et al. 2005). Throughout the Mekong, the Tonle Sap area may be the most vulnerable to hydroclimatic changes given residents' dependence on ecosystem services for their livelihoods (Nuorteva et al. 2010). For example, Gum (2000) estimates that fish and fish products provide up to 75% of Cambodians' daily animal protein intake.

Aside from climatic factors, human developments elsewhere in the region will also impact the country's hydrological flows and therefore agriculture and fisheries sectors. Large-scale, upstream hydropower dam construction in China and Laos and dredging works to improve navigability along the upper Mekong River are just two examples that will pose downstream hydrological and ecological impacts (Sokhem and Sunada 2006). In isolation, these developments are anticipated to shift monsoonal flood timings, flood season volumes, and annual minimum flow timings (MRC 2009b). When coupled with the broader socio-economic dynamics driving them, these changes, according to the IPCC, are likely to overshadow the effects of climate change on fisheries (Easterling et al. 2007).

i. Agriculture

A recent, multilateral-sponsored baseline study stated that the Cambodian government on its own lacks the ability "to bear the total cost of safeguarding food security in the country," (GEF 2009) highlighting existing vulnerabilities in the agriculture sector that will be exacerbated by climate change. Combined with the fisheries sector, the two account for more than 75% of the country's labor force (ILO 2010) and contributed 32% to GDP in 2008 (National Institute of Statistics 2009). Rice is the country's largest commodity with nearly 2.7 million hectares, 15.3% of total land area, under paddy production. Though rice productivity levels are among the lowest in ASEAN because of low usage of fertilizers and improved seed varieties (ASEAN 2010; Johnston et al. 2010), the crop still contributes $1.4 billion to the economy (FAO 2010).

Crop yield responses from various GCMs are strongly nonlinear, with yield gains resulting from temperature and precipitation increases up to a threshold point and then dropping. Projections based on the HadCM2 GCM predict positive crop yield changes of 5–30% for the 2020s–2080s, incorporating the effects of carbon dioxide fertilization (Rosenzweig et al. 2001). A CSIRO team projects 2030 rice yields to be equivalent to historical levels for the Kratie, Tonle Sap, and Phnom Penh regions, but nominal median losses for rain-fed and upland rice. However, the output range from their 11-model suite is wider for the latter, with potential losses of 10% (Eastham et al. 2008). Across the basin, their 2030 projection results in a net productivity gain of 3.6% using the assumption that all rain-fed and irrigated crops are under rice cultivation. The Mekong River Commission synthesizes available impact forecasts and finds marked unevenness across Cambodia. Whereas the Tonle Sap and Kratie

areas experience stronger agricultural productivity, the southern regions can expect food scarcity, reduced crop productivity, and increased flooding (MRC 2009a).

ii. Fisheries

In an international comparison of fisheries' vulnerability to climate change, Cambodia ranked in the top quartile of the 132 reviewed countries because of the sector's significance in supporting livelihoods and caloric intake (Allison et al. 2009). The per capita consumption of fish and other aquatic animals for the 95% of Cambodians who live in the Lower Mekong Basin (LMB) exceeds 52 kg/year, representing the primary protein source when compared to consumption levels below 10 kg/year of all other animals (Hortle 2007). While the LMB is a dynamic system, climate change impacts could threaten ecosystemic balance with higher rainfall levels leading to larger dry and wet season lake areas. Fish species whose populations correlate with annual flood patterns may be subject to boom-bust cycles aggravated by heightened hydrological variability (WorldFish Center 2009). Eastham et al. (2008) identify the need for further research to better understand the intricate relationships between lake levels, fish stocks, and floodplain ecology.

iii. Health and Disease

Given Cambodia's tropical climate, malaria and dengue fever are the two most significant climate-related health factors for the country. The number of people with malaria was estimated at 500,000 earlier in the decade (Ministry of Environment 2002), though a significantly smaller number seek care in public or private health centers. The death toll from malaria has been on the scale of 250–500 since 2003, ranking the country highest in Southeast Asia in malaria mortality rate. This impact could be reduced by expanding education about prophylactic measures and treatment since much of the population continues to rely on traditional, but ineffective medicine. Interviewees from seven provinces identified cost as the greatest determinant in choosing a treatment method (RGC 2006). The Initial National Communication found a positive correlation between malaria incidence and wet season rainfall, but a negative relationship with dry seasonal rainfall. Dengue fever rates fluctuate greatly, with nearly 40,000 cases registered in 2007 and less than 10,000 in 2008 (WHO 2009).

4.2 Recent trends

DanChurch Aid/Christian Aid's (2009) literature review summarizes the natural disasters affecting Cambodia since 1994. In accord with the NAPA and other government documents, they find that floods and droughts are responsible for the greatest damages. Of the 24 provinces and autonomous municipalities, 12 had suffered at least eight years of both floods and drought over a ten-year period (Ministry of Environment 2005). Parts of the country experienced some of the worst flooding of the previous 70 years from 2000–2002, with several million people affected and damages in excess of $200 million (Sokha 2004). Several thousand homes were destroyed and significant crop losses resulted in widespread food shortages. Similarly, droughts from 2002–2004 affected more than 2 million people and damaged between 60,000 and 135,000 ha of rice. More recently, droughts in 2009 affected more than 40,000 ha of rice production (DanChurch Aid/Christian Aid 2009).

Actual changes in weather are one factor in driving adaptation actions, but so are perceptions of changes, even if they are incorrect. In one of the focus group discussions we held, villagers from Krao Bao stated their perception that weather fluctuations from the previous 5–10 years had been relatively normal, but that the duration and intensity of the

2009 flood and the drought of 2010 were more extreme. Villagers elsewhere recounted to us how chickens, ducks, pigs, and cows have been dying in greater numbers because of what they considered to be extraordinarily hot weather. However, the same DanChurch Aid/ Christian Aid report observed discrepancies in how villagers ranked the relative severity of floods and droughts against historical records. Whereas government reports indicate that flooding is a greater concern, respondents in the four surveyed provinces voiced more worry about drought.

5 Background and details of the project

The UNDP-initiated 'Promoting Climate-Resilient Water Management and Agricultural Practices in Rural Cambodia' (henceforth PCRWM) project is the first to be implemented from the NAPA list of proposed activities. The four-year project began implementation in the second half of 2010 and is budgeted at US$4.2 million, with the LDCF and UNDP jointly providing $3 million. Co-financing partners include Agence Française de Développement (AFD) and the Royal Government of Cambodia through in-kind contributions. The Ministry of Agriculture, Fisheries and Forestry (MAFF) is the lead executing agency of the project and also the chair of the Project Board which includes the Ministry of Water Resources and Meteorology (MOWRAM), the Ministry of Environment, UNDP, International Fund for Agricultural Development (IFAD), and AFD. Province-level stakeholders are closely involved in the project's implementation and technical support services. For example, the deputy governor chaired and senior representatives from the Provincial Departments of Agriculture, Water Resources and Meteorology, Environment, and Women's Affairs presented at the UNDP Community Forum in Preah Klaing Commune. These departments and other line agencies form an 11-member Executive Committee that meets at the governor's office and deliberates over project proposals submitted by commune councils, selecting priority projects to fund in each budget cycle.

The primary objective of the PCRWM is to enhance the capacity of local government and communities to integrate long-term climate risks into policy and decision-making. By adopting a preemptive approach to natural disasters and transitioning away from the reactive nature of existing policies that make only casual reference to climate change in national planning, the project aims to safeguard both food and human security (UNDP 2008). These objectives complement existing national policies, such as MAFF/MOWRAM's "Strategy for Agriculture and Water 2010–2013" and the government-wide "Rectangular Strategy for Growth, Employment, Equity and Efficiency in Cambodia" announced by Prime Minister Hun Sen in 2004. Towards that end, more than three-quarters of project funds are allocated for technical assistance in three areas: capacity development; demonstration and analysis of adaptation options; and replication, dissemination and knowledge transfer (GEF 2009).

Project documents originally targeted Siem Reap and Battambang provinces for implementation, but to increase inter-project synergy developers later selected Preah Vihear and Kratie provinces where IFAD is implementing a Rural Livelihoods Improvement Project (RULIP) with MAFF. Kratie scores in the 'quite vulnerable' category in regards to flooding as per an assessment of the erstwhile Cambodia Climate Change Office, though both provinces are ranked as 'low vulnerability' for droughts (RGC 2006). Many of the communities living in the targeted districts in Preah Vihear and Kratie practice subsistence farming and are therefore reliant on agriculture for their livelihoods. In the Preah Vihear districts we visited, rice cultivation is the dominant activity as depicted in Fig. 4, with some households engaging in animal husbandry, particularly cows, buffaloes, chickens, and

Fig. 4 Organic rice cultivation in Krao Bao Village, Preah Vihear Province

ducks. Villagers grow a variety of fruits and vegetables including eggplant, pumpkin, morning glory, ginger, taro, pineapple, and corn. Most of the yield is consumed within the house or community, leaving a relatively small volume to be sold at the market on an occasional basis. Interviewees indicated this could provide a household with an extra $5 per week.

6 Benefits of the PCRWM

In this section and the next, we examine the project's benefits and challenges through the lens of three forms of resilience: institutional, infrastructural, and community. Our interpretation of resilience is consistent with the literature (e.g., Adger 2000; Klein et al. 2003; Folke 2006), where we take resilience to mean an agent's ability to withstand changes in the surrounding environment, either physical, political, or economical. Institutional resilience refers to the stability of governmental bodies, at local and national levels, towards maintaining their core functions despite stressors in the policy environment. Community resilience represents the social cohesion that safeguards livelihoods, effectively and rapidly resolves disputes, and binds together community-based organizations. Community resilience can also be seen as the dialectical relationship of individuals among a collective and the social ties they maintain. Lastly, infrastructural resilience encompasses interventions conventionally accepted as 'hard,' like sea-walls, as well as softer options like climate information systems and modern seed varieties.

6.1 Institutional resilience

Building the capacity of relevant government offices will be one of the project's key components. Through collaboration with programs already implementing capacity-building in the sector, this project will integrate "anticipatory climate risk management and climate change adaptation" elements (UNDP 2008). Core functions to be addressed are planning, budget management, and policy. The project aims for Commune Councils' Planning and Budgeting Committees to devise commune development plans based on long-term climate forecasts and scenarios, budgeting for water resources investments that are appropriate given anticipated risks. Another objective is to inform the Ministry of Environment's process of devising sectoral policy at the national level through lessons learned in the course of the project.

While the UNDP supports capacity-building efforts to support the ministries and national governing bodies tasked with climate change work, the PCRWM's energies, however, will be concentrated on officers at the provincial level where most community-public engagement will occur. Training agricultural extension workers will be vital, as they will oftentimes be the front-line interface with villagers seeking agronomic support, including seed variety selection, timing of seeding and harvesting, irrigation practices, and appropriate application of soil conditioners.

The project's capacity-building aimed at provincial and community-levels coheres with Cambodia's ongoing decentralization reforms which were initiated in 2002 with the first democratic election of Commune Councils (Romeo and Spyckerelle 2004). As government bodies at these levels absorb newly-devolved administrative and fiscal responsibilities, the opportunity exists to change the paradigm by which climate-related actions are executed. Instead of responding to disasters after the fact, capacity-building efforts intend to reform the planning processes and incorporate long-run climate forecasts and model output into ongoing decisions. Thus far, provinces have only been able to address immediate needs and lacked the resources to consider longer-term requirements. Climate-proofed infrastructure investments and agricultural extension practices can then be implemented which minimize long-run losses and safeguard local populations against climate impacts. According to Chambwera and Stage (2010), by achieving donor integration in existing policy channels, or unfolding ones as is the case here, the likelihood of adaptation action success is higher than when operating outside the existing policy apparatus. At the same time, successful integration is predicated on effective knowledge and information-sharing mechanisms in addition to capacity-building (Brockhaus and Kambire 2009). As such, the standing structure of Commune Councils and commune meetings, such as seen in Fig. 5, provide an obvious conduit in reaching residents and involving them in capacity-building efforts.

Capacity-building at this level will be especially important given the large scaling-up of funds and project execution expected in upcoming years. Aid agencies, bilateral and multilateral, have already expressed interest in project development with local partners, but need assurance that competent staff will serve as implementing partners. One consultant working on rural development issues said that "climate change is a very new concept. Most people do not know about climate change, even the NGOs. Some donors have allocated funds for climate change projects, but don't know who can implement them and the NGOs don't know how to get those funds." If the project's capacity-building efforts prove successful in the piloted provinces, then lessons can be transferred to other provinces where adaptation aid funding is expected to be directed.

Fig. 5 Residents and commune council members in Preah Vihear Province

Another feature of the project is its objective to promote collaboration and coordination among different government bodies. Cambodia already recognizes climate change's cross-cutting nature as demonstrated in the National Committee on Climate Change's 19-ministry membership. At the provincial level, this assumes the form of an Executive Committee whose membership resembles the NCCC's, which is collectively tasked with executing NAPA-based projects. To prompt inter-ministerial cooperation, UNDP has established a Project Management Unit (PMU) that brings together several ministries, each delegated roles where they exhibit "a comparative advantage to deliver […] results" (UNDP 2008).

Though the PCRWM is described as a 'learning by doing' project, the knowledge-sharing associated with the 'doing' constitutes a third form of promoting institutional resilience, with differentiated strategies for reaching domestic and foreign audiences. Within Cambodia, project outcomes will be reported to relevant ministries and bodies like the Technical Working Group on Agriculture and Water and other TWGs. To reach a broader population of interested parties, project findings will be communicated through the Adaptation Learning Mechanism (ALM) website, an initiative sponsored by the World Bank and several UN agencies. The ALM is open-access and hosts a resource library of global interest, featuring downloadable, adaptation-focused resources like project reports and practitioner guides, and is available for institutional and personal use.

6.2 Community resilience

In addition to devolving ministerial functions to local levels where possible, the decentralization reforms also shift more responsibility onto community groups. The maintenance of secondary and tertiary canals, for example, are now under the domain of farmer water users committees (FWUCs), and at the time of project document publication, provincial Departments of Water Resources and Meteorology had already established 370 such FWUCs (UNDP 2008). Commune councils, composed of elected representatives from the commune's constituent villages, now assume greater budgetary control through mechanisms like the Commune/Sangkat Fund (CSF) (Romeo and Spyckerelle 2004).

Mirroring these changes, this project operates through local bodies like the commune councils, FWUCs, and the Planning and Budget Committees (PBCs) to increase stakeholder ownership and control over commune policy and planning. A recent poll showed the public trusting commune councils more than other levels of government and offering positive reviews of council performance (Ninh and Henke 2005). However, council efficacy has been restricted by the nominal budget that provincial governments have historically allocated to them and the lengthy wait times before disbursement. As one interviewee stated, "Funding for commune projects takes place at the provincial level. One hundred projects may be proposed, but there is only enough money for ten. They prioritize based on their available resources and those that lose get rolled over into the next year. Communes raise a lot of needs and proposals, but government is unable to meet those needs and participation levels." A consequent requirement is to improve financial management systems which would expedite the transfer of funds from international donors to communes and reduce the lead time for completing capital-intensive projects. This will translate into benefits for the communes, some which have articulated their local investment needs, but remain stationary until government approval is secured. One village's residents explained how their plans to construct a dam for water storage are on indefinite hold until funds are released. At the same time, the Asia Foundation poll showed that commune members viewed other infrastructure projects like the construction of roads, schools, wells, and pagodas as significantly more important than irrigation works (Ninh and Henke 2005).

Capacity-building and awareness-raising at the community level is another component. By training villagers in climate-resilient water resources management, providing them access to local climate information systems, and experimenting with pilot studies for alternative cropping techniques, this project aims to empower village stakeholders to make better-informed decisions that can preempt some of the damages expected from extreme weather impacts. Villagers equipped with these tools will then be better able to implement locally-appropriate adaptation actions. The importance of this has been underscored in recent years by geographically uneven weather impacts: some provinces have experienced flooding at the same time others have faced drought.

Since extreme weather events contribute to crop failures, they are also linked to desperation sales. In one FGD, respondents recounted having sold motorcycles, pigs, and cows to purchase rice. If left unchecked, the repetition of such events across a broad enough group could result in social instability. The project features conflict mitigation activities to stave off such potential developments, as well as address long-standing land title disputes which also affect the management of water resources. Examples of successful climate-resilience will be disseminated to the public through TV, radio, and newspaper formats to encourage best practices that minimize climate risk and its negative externalities. This information-sharing is expected to further spur adaptation actions to safeguard against future losses. For example, Nuorteva et al. (2010) found evidence of adaptive responses stemming from prior weather incidents; some of the households affected by major flooding in 2000 have since raised the height of their houses' stilts.

Implicit in project design and indirectly mentioned by reference to LDCF's justification for project support is a poverty alleviation component. Though absent from the monitoring and evaluation framework, an unstated outcome will be an increase in crop output, or conversely, a reduction in disaster-caused crop losses. If the excess crops are sold at market rather than consumed by the household, the marginal gains would translate into a more secure financial status and consequently elevated 'adaptive capacity.' This connection is not overtly made in project documentation, but can be understood as a logical conclusion, unless the cost of the proposed adaptation measures outweighs the profits accrued from greater yields.

6.3 Infrastructural resilience

The targeted districts' immediate irrigation infrastructure needs are well understood by village leaders and local government. One focus group stated that, "Our main problem is the lack of money to fund water diversion. We need to dig a pond in the rice fields and the water could be used for rice planting." Interview respondents referred to retention ponds, canals, dykes, and reservoirs that after years of neglect remain in disrepair. Instead of repairing these irrigation systems using design parameters derived from historical hydrological patterns, the project aims to integrate climate forecasts into their design to avoid system failure because of misspecification. As such, the project will support the rehabilitation of one irrigation system in each province to demonstrate climate-resilient irrigation rehabilitation and maintenance. Further construction or rehabilitation projects will be funded by government allocations.

While government efforts have historically centered on water for irrigation purposes, this project also addresses water resource demands for personal consumption and sanitation. Effective resource management for these purposes would have a knock-on effect of reducing the vulnerability of agricultural water supplies. Towards that end, the project has

allocated $150,000 for rainwater harvesting equipment and will implement demonstration projects in 20 villages. These investments will provide community-wide benefits, with possible systems in Preah Vihear tapping mountain waters or deep well sources. This component satisfies an existing need as interviewed villagers considered the 50,000 riel (US$11.90) harvesting tanks cost-prohibitive. Several households in districts we visited were already engaging in this practice, such as in Sethakich village where all households have harvesting tanks. Other villages like Thanal Bek pump water from a well, but experience queues for its use and poor water availability.

The promotion of alternative seed varieties constitutes another form of adaptation'hardware' and is joined by an anticipated collaboration between farmers and local extension workers who will train farmers in optimal usage. Farmers have in the past depended on traditional seeds and only recently have begun using high-yield seeds from the Department of Agriculture. The Cambodian Agricultural Research and Development Institute (CARDI), a semi-autonomous body housed under MAFF and the Ministry of Economy and Finance, conducts plant breeding to produce drought- and flood-resistant rice varieties which will be supplied to project participants. There are also community seed banks where alternative varieties are available, collecting and disbursing seeds on a revolving basis. Other interviewees referred to the possible incorporation of organic varieties, though not explicitly stated in project documents. An organic rice pilot project is operating in Krao Bao village, and though organic seed varieties are more expensive and labor-intensive, participating villagers said that seedling requirements per hectare are about one-third of non-organic varieties. In addition to the price premium when sold in markets, organic rice also has significant export potential as evidenced in expanding trade relations. In 2009, 2,300 t of organic rice was exported to Malaysia, Europe, and the United States, with an estimated 3,000 t targeted for total exports in 2010 (Xinhua News 2010).

Aside from piloting alternative seed varieties, innovative cropping practices like system of rice intensification (SRI), direct seeding mulch-based cropping (DMC) systems, and crop variety diversification will be promoted by extension workers. Some of these practices, like SRI, are already based on successful in-country experiences. CEDAC, one of the partner organizations, first introduced the method to Cambodian farmers in 2000, with than 80,000 farmers actively practicing it (CEDAC 2008). The method relies on "drained instead of continuously flooded fields during the vegetative crop development stage, the use of locally produced compost rather than mineral fertilizers, and the use of very early transplanting of single, widely spaced plants" (Stoop and Kassam 2005). UNDP has expressed concern about possible soil erosion exacerbated by the practice, which could lead to productivity losses, though still includes it as a potentially resilient farming practice. This component will leverage on the work done by other organizations like CEDAC, Caritas, and the Lutheran World Federation who have already implemented various agricultural projects in throughout Cambodia. These practices will be test-bedded across 30 communities, with successful methods to be scaled-up and extended to other provinces.

7 Challenges to the PCRWM

Various challenges exist among the institutional, community, and infrastructural domains that could affect project success. Project developers have identified several and incorporated risk mitigation measures as a result. The following section addresses the most pertinent challenges these three domains will likely face.

7.1 Challenges to institutional resilience

Prior to project inception, the UNDP had identified inter-ministerial cooperation as an anticipated challenge, citing failed attempts in earlier multilateral-supported initiatives as proof. Cooperation through this project may be compromised by competing visions for how to achieve common objectives. For example, the involved organizations support the strengthening of food security, but do not necessarily agree on the means to achieve it. Whereas CEDAC ardently supports organic practices and traditional seeds, MAFF is a proponent of fertilizer application and hybrid seed varieties to improve yields. Likewise, some government departments consider road-building and market development more urgent needs than rehabilitating irrigation infrastructure. Challenges are therefore anticipated in reconciling competing views on service delivery given differing outlooks on the role of technology, innovation, and prioritization, unless mutually incompatible practices are adopted in different areas.

Cooperation through this project can be seen as a prerequisite for the success of future adaptation work after UNDP/GEF support expires, given the cross-cutting effects of climate impacts that do not fall neatly into the domain of any single ministry. The establishment of a project management unit aims to secure that cooperation, but runs the risk of 'erasing' experiences once the project concludes. As per Godfrey et al.'s (2002) review of development projects in Cambodia in the late 1990s, one interviewee states that "the key to capacity building is to work through government structures. Projects with a separate office and a Project Implementation Unit will leave nothing when they go." Accordingly, lesson-sharing across province- and district-level agencies will be valuable, but only the lesson can be transferred: experiences and institutional arrangements cannot. Donors can play a role in convening district staff with varying levels of adaptive intervention experience, but would ideally be performed by ministry-level actors or cross-ministry Technical Working Groups. An overview of such discussions is missing from project documents and fractures among involved ministries already seem apparent. One senior MOE official claimed the ministry had only "indirect involvement with UNDP's projects," despite the MOE's former role as Executing Agency for the PCRWM and its continued role as a Senior Beneficiary in the Project Board.

Another challenge project developers face is in demonstrating to policymakers the value of incorporating climate risk projections into policy and planning. This is doubly difficult because the average government officer possesses minimal knowledge about climate change's drivers or impacts and therefore may not see the necessity of such a project. As one senior officer said, "Our biggest need is for staff who understand the basic concepts of climate change. We need people who are interested. We have the resources—the reports, internet access—maybe this is a government salary issue where the incentives are too low?" In comparison to other social development priorities like education and health, officials may deem climate change a lower priority (IISD 2009), in terms of deserving funding and manpower. While this is less problematic for no-regrets projects like this, where net benefits are anticipated regardless of the severity of climate change, it is a tangible concern for projects whose investments may not reap visible dividends. Throughout, officers who are dubious of the value of climate-resilience projects may simply dismiss them as the next 'development fad' and therefore commit insufficient resources to ensuring project success. This would be detrimental to attracting donor support to fund an up-scaling of adaptation interventions.

7.2 Challenges of community resilience

The desired outcome for this and other adaptation projects is to translate capacity-building and awareness-raising activities into behavioral or technological actions that are responsive

to climate risk factors. Success can be measured in multiple ways, including the number of people that have received training or the degree to which they have integrated new information into their practices. The ultimate goal is to change habits, but abandoning traditional habits and practices will not happen immediately. They are historically embedded and may be justified by irrational reasoning. As an example, when asked what actions they take to cope with drought, nearly one-quarter of respondents in the NAPA survey stated that they conduct religious ceremonies to induce rainfall (RGC 2006). About 16% continued their cropping patterns as usual. While these may be inconvenient choices caused by a shortage of alternatives, there is no guarantee that farmers will adopt new methods even if the option of modern seed varieties or inter-cropping is available. Traditional practices are familiar whereas these are not. One Department of Agriculture official recounted earlier efforts to encourage crop rotation and to plant vegetables in the paddy after the rice harvest. Farmers were not adopting this practice because "for a long time they have only grown rice."

This of course will not be universal. Focus group participants expressed enthusiasm for trying new practices, but other barriers besides tradition can impede adoption. Another factor may be ex ante or ex post risk aversion. Project Board staff understand there are no guarantees and that project participants may not experience positive gains from an adaptation action. Sewing drought-resistant seeds could decrease harvests if precipitation levels are normal or higher since they are specially bred for drought conditions (Patt and Schröter 2008). Whereas success from the Project Board's perspective is the application of these practices, informed by the maximum available information, success from the farmer's perspective is an increased yield. Farmers' willingness to continue participating would understandably drop in the event of yield losses.

In such a case, there are two factors to untangle. One is that adaptation actions will not necessarily result in productivity gains. The other is that losses below average yield are costly, especially for subsistence farmers who would either cut back their consumption levels or offset their shortfall by purchasing the difference in the local market. Given the low per-capita earnings of these districts, there is not much room for error and households cannot write-off such losses with ease. While the potential, amortized benefits of adaptation may be cost-justified, upfront costs of participation (e.g., more expensive seeds, soil conditioner requirements) or longer-term lost revenues may be dissuading factors for sustained adaptation. Scaled-up to the community level, uncertainty about the payoff matrix associated with adaptation investments may cause disagreement over how best to utilize commune funds. Commune members will have attended awareness-raising workshops and therefore will be sensitized to the need to size infrastructure according to long-term needs, in the form of larger ponds and wider canals for example, but will they be willing to pay the additional cost over specifications that would be suitable for immediate needs? Donors will soon initiate an inflow of climate funding that might be sufficient to offset those marginal costs, but at the same time communes must strategize as to their other investment needs (e.g., schools, hospitals, roads) that might provide better value for money in both the immediate and longer terms.

7.3 Challenges to infrastructural resilience

Devolving policy and planning functions to the provincial and commune level will empower local stakeholders, but at the same time introduces a new set of coordination issues. In the absence of an overarching administrative structure, geographic jurisdictions utilizing a common water body may come into conflict without the resolution mechanisms

to remedy it. What is intended to be an effective adaptation strategy for some individuals may end up as maladaptive for those not involved in devising the strategy. For example, districts that improve their water resources infrastructure may enjoy access to greater withdrawal volumes that increase output from irrigated croplands. At the same time, it may increase the vulnerability of downstream users who were not involved in the original decision-making and may have limited legal recourse (Barnett and O'Neill 2010). Though only 7% of Cambodia's crop area is irrigated (UNDP 2010a), this number will rise and these coordination issues consequently grow in importance.

Maladaptation may also result from using inaccurate or incomplete impact forecasts. The Ministry of Environment (MOE) is actively working to improve upon the modeling conducted during the Initial National Communication for the Second National Communication, by working with a larger GCM ensemble and with regionally down-scaled data. As ministries shift towards using model ensembles and triangulating forecasts against those made by neighbor countries or other international organizations, there will then be greater clarity about anticipated impacts. However, many of the problems with seasonal climate forecasting among that Mason (2003) observed in his 2002 'fact-finding mission' likely still apply, including his assessment that "a typical United States climatologist has more computing power in their own office for their personal use than there is throughout the entire building of the Department of Meteorology in Phnom Penh (*sic*)." To date, staff and skills shortages remain a problem for Cambodian ministries as does access to current computing technologies. Many of the weather monitoring stations that were destroyed during the Pol Pot era have not been replaced which further exacerbates the problem of acquiring reliable seasonal forecasts (Ministry of Environment 2005).

Even if newer technology could generate reliable data, significant uncertainty about which emissions trajectory the global economy will follow and how this will translate into local climate impacts is an intractable reality. Though some projects are justifiably no-regrets measures, others may only provide benefits under a range of climatic conditions. Yet adaptation actions need to be made based on the information that is available, albeit cognizant of the probabilistic nature of scenario projections. Attempts at simplifying these uncertainties by presenting a single probability distribution can lead policymakers to discount low-probability, but high-damage outcomes and enact policies that are maladaptive (Hall 2007). Acting on information that is ultimately inaccurate can at best result in wasted funds on poorly designed infrastructure, and avoidable loss of property and human life at worst. Instead, policymakers should adopt flexible strategies that afford protection even in the face of high outcome variability, and retain the ability to modify those strategies as information about changes in outcome become available (Lempert et al. 2000). It is not clear how uncertainty about future impacts is incorporated into the irrigation system redesigns that are envisioned, especially if commune members are responsible for designating system specifications.

8 Conclusion

We offer conclusions for both Cambodian planners as well as those concerned with climate change adaptation more generally.

For planners in Cambodia, the extensive damages wrought by recent natural disasters, especially droughts and flooding, are likely to serve as a prelude to more such events to come. Interviewed villagers referred to specific instances in the past decade as proof of climate change and have expressed interest in projects like the UNDP's "Promoting Climate

Resilient Water Management and Agricultural Practices in Rural Cambodia" to safeguard their harvests against extreme weather. The project aims not only to support adaptation measures like system of rice intensification (SRI) farming, the use of flood- and drought-resistant seed varieties, and rainwater harvesting that collectively improve food security, but also to mainstream climate change issues into policy and planning at local levels. Doing so will ensure that decisions with long lifetimes, such as infrastructure investments, are responsive to the best available information on future climate risks, as well as encouraging farmers to adopt practices that will improve their own resilience to climate change. Through careful and long-term planning, water resources infrastructure and agricultural practices can be designed to withstand climate variability and avoid the need to replace or rehabilitate systems whose specifications were prematurely determined.

Since the project is responding to several historical needs—dilapidated irrigation networks, poor crop productivity levels, and weak intra-governmental coordination when responding to cross-cutting issues—project measures could rightfully be seen as constituting a development project more than an adaptation project. As low per capita income is the country's biggest drag on adaptive capacity (especially highlighted when comparing Cambodia's relatively mild range and intensity of natural disasters against those experienced by neighbors like the Philippines and Indonesia), this provokes the question of whether more resources should be spent on measures to raise household income as a climate change response mechanism. However, since the project collaborates with initiatives like the Rural Livelihoods Improvement Project (RULIP), under the same implementation agency as the PCRWM, then there will likely be a component of diversifying into new income-generating activities and accessing credit to purchase equipment like tractors and motorized water pumps that could increase crop productivity. When these measures come into place, villagers will find that additional income enables them to adopt climate-appropriate agricultural practices, generate savings to recover from crop losses, and fortify their homes and other assets against the effects of climate change. The PCRWM project demonstrates that accomplishing those goals will require the cooperation of the numerous ministries and provincial departments involved, as well as the participation of villagers who recognize that long-term climate risk mitigation can yield both immediate and long-term benefits.

For those concerned with adaptation on an international scale, and less with Cambodia in particular, our study highlights the salience of promoting multiple forms of resilience at once. Officials in Cambodia are not only experimenting with crops and rehabilitating canals and ponds, but educating provincial officials and empowering local villagers to decide on infrastructure investments. Their efforts imply that truly resilient societies must improve adaptive capacity related to technology, institutions, and community assets simultaneously. Emphasizing only one type of resilience, or adaptation in one sector, does nothing to improve the others and thus leaves them at the risk of climate-induced disasters and vulnerabilities.

References

ADB (2009) Under the weather and the rising tide: adapting to a changing climate in Asia and the Pacific. Asian Development Bank, Manila

Adger WN (1999) Social vulnerability to climate change and extremes in Coastal Vietnam. World Dev 27:249–269

Adger WN (2000) Social and ecological resilience: are they related? Prog Hum Geogr 24:347–364

Adger WN, Agrawala S et al (2007) Assessment of adaptation practices, options, constraints and capacity. In: Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE (eds) Climate change 2007:

Impacts, adaptation and vulnerability. Conrtibution of working group II to the fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge
Allison EH, Perry AL et al (2009) Vulnerability of national economies to the impacts of climate change on fisheries. Fish Fish 10:173–196
ASEAN (2010) ASEAN early warning information. ASEAN Food Security Information System Office, Bangkok, 4
Ayers J, Alam M et al (2010) Global adaptation governance beyond 2012: developing-country perspectives. In: Biermann F, Pattberg P, Zelli F (eds) Global climate goverance beyond 2012. Cambridge University Press, Cambridge, pp 270–285
Barnett J, O'Neill S (2010) Maladaptation. Glob Environ Change 20:211–213
Brockhaus M, Kambire H (2009) Decentralization: a window of opportunity for successful adaptation to climate change? In: Adger WN, Lorenzoni I, O'Brien KL (eds) Adapting to climate change: thresholds, values, governance. Cambridge University Press, Cambridge, pp 399–416
CEDAC (2008) Report on national prizes for best SRI farmers in 2007
Chambwera M, Stage J (2010) Climate change adaptation in developing countries: issues and perspectives for economic analysis. International Institute for Environment and Development, London
Cruz RV, Harasawa H et al (2007) Asia. Climate change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, pp 469–506
DanChurch Aid/Christian Aid (2009) Public perceptions of climate change in Cambodia. Phnom Penh
Easterling WE, Aggarwal PK et al (2007) Food, fibre and forest products. In: Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE (eds) Climate change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, pp 273–313
Eastham J, Mpelasoka F et al (2008) Mekong river basin water resources assessment: impacts of climate change. Water for a Healthy Country National Research Flagship, CSIRO
Economics of Climate Adaptation Working Group (2009) Shaping climate-resilient development: A framework for decision-making. Washington, DC, Global Environment Facility, European Commission, McKinsey & Company, The Rockefeller Foundation, Standard Chartered Bank, and Swiss Re
FAO (2010) FAOSTAT. Retrieved 17 Aug 2010, from http://faostat.fao.org/
Folke C (2006) Resilience: the emergence of a perspective for social-ecological systems analyses. Glob Environ Change 16:253–267
GEF (2009) Request for CEO Endorsement/Approval. Project ID: 3867
GEF (2010) Least developed countries fund. Retrieved 7 September, 2010, from http://www.thegef.org/gef/LDCF
Godfrey M, Sophal C et al (2002) Technical assistance and capacity development in an aid-dependent economy: the experience of Cambodia. World Dev 30:355–373
Gum W (2000) Inland aquatic resources and livelihoods in Cambodia: A guide to the literature, legislation, institutional framework and recommendations, Oxfam GB and NGO Forum on Cambodia
Hall J (2007) Probabilistic climate scenarios may misrepresent uncertainty and lead to bad adaptation decisions. Hydrol Process 21:1127–1129
Hoanh CTH, Guttman et al (2003) Water, climate, food, and environment in the Mekong Basin in Southeast Asia
Hortle KG (2007) Consumption and the yield of fish and other aquatic animals from the lower Mekong Basin. MRC Technical Paper No. 16. Vientiane, Mekong River Commission: 87
Huq S, Rahman A et al (2003) Mainstreaming adaptation to climate change in least developed countries (LDCs). International Institute for Environment and Development, London
IISD (2009) Least Developed Countries. Retrieved November 3, 2010, from http://www.iied.org/climate-change/key-issues/climate-negotiations-capacity-building/least-developed-countries
ILO (2010) LABORSTA. Retrieved 17 Aug, 2010, from http://laborsta.ilo.org/
Jerneck A, Olsson L (2010) Shaping future adaptation governance: perspectives from the poorest of the poor. In: Biermann F, Pattberg P, Zelli F (eds) Global climate goverance beyond 2012. Cambridge University Press, Cambridge, pp 286–305
Johnston R, Hoanh CT et al (2010) Scoping study on natural resources and climate change in Southeast Asia with a focus on agriculture. International Water Management Institute, Southeast Asia (IWMI-SEA)
Keskinen M, Kakonen M et al (2007) The Tonle Sap Lake, Cambodia: water-related conflicts with abundance of water. Econ Peace Secur J 2:49–59
Klein RJT, Nicholls RJ et al (2003) Resilience to natural hazards: how useful is this concept? Glob Environ Change B Environ Hazards 5:35–45
Kummu M, Koponen K et al (2005) Assessing Impacts of the Mekong Development in the Tonle Sap Lake. Proceedings of the International Symposium on Role of Water Sciences in Transboundary River Basin Management. Ubon Ratchathani, Thailand

Lempert RJ, Schlesinger ME et al (2000) The impacts of climate variability on near-term policy choices and the value of information. Clim Change 45:129–161
Lum T (2007) Cambodia: Background and U.S. relations. Congressional Research Service Report for Congress: RL32986
Margulis S, Bucher A et al (2008) The economics of adaptation to climate change: methodology Report. World Bank Group, Washington, DC
Marshall NA (2010) Understanding social resilience to climate variability in primary enterprises and industries. Glob Environ Change 20:36–43
Mason S (2003) Seasonal climate forecasting. Tiempo 47
McGray H (2009) The national adaptive capacity framework: key institutional functions for a changing climate. World Resources Institute, Washington, DC
McSweeney C, New M et al (2008) UNDP Climate change country profiles: Cambodia
Ministry of Environment (2002) Cambodia's initial national communication
Ministry of Environment (2005) Analysis of policies to address climate change impacts in Cambodia
MRC (2009a) Adaptation to climate change in the countries of the lower Mekong Basin: Regional Sysnthesis Report. MRC Technical Paper No. 24
MRC (2009b) Modelling the flow of the Mekong. MRC Management Information Booklet Series No. 3
National Institute of Statistics (2009) Summary of GDP economic activity 2008. Retrieved 17 Aug, 2010, from http://www.nis.gov.kh/index.php/statistics/national-accounts
Ninh K, Henke R (2005) Commune councils in Cambodia: a national survey on their functions and performance, with a special focus on conflict resolution. The Asia Foundation, San Francisco
Nuorteva P, Keskinen M et al (2010) Water, livelihoods and climate change adaptation in the Tonle Sap Lake area, Cambodia: learning from the past to understand the future. J Water Climate Change 01:87–87
Patt AG, Schröter D (2008) Perceptions of climate risk in Mozambique: implications for the success of adaptation strategies. Glob Environ Change 18:458–467
Pettengell C (2010) Climate Change Adaptation: Enabling people Living in Poverty to Adapt. Oxfam International Research Report, Oxfam International
RGC (2006) National Adaptation Programme of Action to Climate Change (NAPA). Ministry of Environment, Phnom Penh
RGC (2010) Acceptance of offer to participate in the pilot program for climate change resilience
Romeo LG, Spyckerelle L (2004) Decentralization reforms and commune-level services delivery in Cambodia. Local Government Pro-Poor Service Delivery Workshop, Manila
Rosenzweig C, Iglesias A et al (2001) Climate change and extreme weather events; implications for food production, plant diseases, and pests. Glob Change Hum Health 2:90–104
Royal Embassy of Cambodia (2006) Cambodia's poverty rate falls. Cambodia in Focus
Scheuer J (2010) Launch of Cambodia climate change alliance: Opening remarks. Retrieved 25 August, 2010, from http://www.un.org.kh/undp/Climate-Change/Launch-of-Cambodia-Climate-Change-Alliance.html
Snidvongs A, Choowaew S et al (2003) Impact of climate change on water and wetland resources in Mekong River Basin: Directions for preparedness and action. Southeast Asia START Regional Center Report #12
Sokha K (2004) Kingdom of Cambodia: national committee for disaster management. Regional Workshop on Methodologies of Assessment of Socio-Economic Impacts of Disasters in Asia and their Application for Poverty Eradication and Economic Development, Bangkok
Sokhem P, Sunada K (2006) The governance of the Tonle Sap Lake, Cambodia: integration of local, national and international levels. Water Resour Dev 22:399–416
Stoop WA, Kassam AH (2005) The SRI controversy: a response. Field Crops Res 91:357–360
UNDP (2008) UNDP Project Document: PIMS no. 3687, Promoting Climate-Resilient Water Management and Agricultural Practices in Rural Cambodia
UNDP (2010a) Cambodia case study: Promoting climate resilient water management and agricultural practices in Rural Cambodia
UNDP (2010b) New course of action in Cambodia's alliance against climate change. Retrieved October 27, 2010, from http://www.un.org.kh/undp/pressroom/events/new-course-of-action-in-cambodias-alliance-against-climate-change August 23, 2010
United Nations Development Program, United Nations Environment Program, et al (2008) World Resources 2008: Roots of Resilience, Growing the Wealth of the Poor Washington, DC, UNDP, UNEP, World Bank, WRI
Västilä K, Kummu M et al (2010) Modelling climate change impacts on the flood pulse in the Lower Mekong floodplains. J Water Climate Change 01:67–86
Venema HD, Cisse M (2004) Seeing the Light: Adapting to Climate Change with Decentralized Renewable Energy in Developing Countries Winnipeg, Manitoba, International Institute for Sustainable Development
WHO (2009) Health system country profile: Cambodia

World Bank (2010) World development indicators. Retrieved November 18, 2010, from http://data.worldbank.org/

WorldFish Center (2009) Climate change and fisheries: vulnerability and adaptation in Cambodia

Xinhua News (2010) Cambodia to export 3,000 tons of organic rice

Young OR (2010) Institutional dynamics: resilience, vulnerability, and adaptation in environmental resource regimes. Glob Environ Change 20:378–385

Yusuf AA, Francisco H (2009) Climate change vulnerability mapping for Southeast Asia. Economy and Environment Program for Southeast Asia (EEPSEA), Singapore