Drought Risk in Cambodia: Assessing Costs and a Potential Solution

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ABSTRACT

The two major natural hazards that threaten Cambodia are flood and drought. Millions of people have been affected by these natural disasters which have put to waste millions of hectares of paddy rice lands on which depend the lifeblood of the rural economy as well as that of the whole country. Given the dire consequences posed by drought to the Cambodian economy, and in light of its short- and long-term development plans aimed at poverty reduction, the government has affirmed its priority for agricultural development. Targeting the most vulnerable areas, this study aims to estimate the costs of drought in two communes in the rural Kampong Speu province, and to assess the costs and benefits of rehabilitating an unused water reservoir. The costs of drought are estimated at the household level. Household questionnaires were used to collect data from households from two rice ecosystems (totally rainfed and supplementary-irrigated) in the Kampong Speu.

The study finds that the expected loss from drought for farmers in rainfed areas is USD 51.47 per hectare while that for farmers in supplementary-irrigated areas is USD 23.01 per hectare. Looking at the prospects for rehabilitating a totally damaged reservoir, the study reports that at a 6 percent discount rate, the repair efforts will yield a net present value of around USD 914,834.94 and the benefit-cost ratio is 2.18. The rehabilitated reservoir is seen to serve two significant roles, namely: (1) to stabilize and increase rice production since drought susceptibility among farmers is reduced and food security is ensured and (2) to encourage agricultural diversification.

Keywords: drought, agriculture, adaptation
JEL Classification: D61, O13, Q15

INTRODUCTION

Drought and flood have been recognized as major natural hazards in Cambodia (MoE 2001; RGC 2010; WFP 2003; World Bank 2006). These have affected millions of people and destroyed paddy rice fields (EM-DAT 2012), which provide the main source of rural livelihood and serve as the backbone of the Cambodian economy. Due to the country's geography, which varies greatly both in terrain and in proximity to water, the frequency of natural hazards differs from province to province. The three provinces that are most vulnerable to climate change and, therefore, the most prone to natural hazards are Mondol Kiri, Rotanak Kiri, and Kampong Speu (Yusuf and Francisco 2010). Of these three provinces, Kampong Speu has been the most severely affected by drought, based on the physical damage, particularly to paddy rice (MAFF 1999–2010).

Cambodian farmers use two different watering methods: rainfed and supplementary irrigation. Some farmers totally depend on rainfall to water their crops (from here on referred to as rainfed farmers), while others (which shall be referred to as supplementary farmers) use both rainfall and other sources of water such as reservoirs and lakes. Rainfed farmers in Cambodia are very vulnerable to drought, and securing water for these farmers is the key to reduce this vulnerability (Chhinh and Cheb 2014).

Drought can be defined in a number of ways, including meteorological (where there are prolonged periods with lower than average precipitation), agricultural (where there is not enough precipitation to meet the agricultural needs of a region), hydrological (where water reserves fall below average), and socioeconomic (where the demand for an economic good exceeds supply as a result of water shortage) (UNISDR 2007; Wilhite and Glantz 1985). All definitions of drought have as their entry point the deficits of water for domestic consumption and/or an established economy (McKee, Doesken, and Kleist 1993). Regardless of the definition criteria, the temporal and spatial distribution of rainfall is a key issue in any kind of drought (Heim 2002; Wilhite and Glantz 1985). For instance, in the case of rainfed paddy rice production, both the total amount and temporal distribution of rainfall are very critical to inputs and productivities (Ros, Nang, and Chhim 2011). In this paper, the definition of drought is based on the social perception of farmers who view it as the lack of an adequate amount of water to meet their needs.

The Royal Government of Cambodia sees drought as a threat to the Cambodian economy and is focusing on agricultural development as part of their short- and long-term development plans for addressing poverty reduction. For example, the *National Strategic Development Plan Update 2009–2013* shows a commitment to further rehabilitate and construct physical infrastructure so that the agricultural sector, especially paddy rice productivities, will be promoted (RGC 2010). Agricultural experts in Kampong Speu support this policy and, in order to deal with the effects of drought, request the rehabilitation of the Kvet Reservoir, an irrigation facility that was deactivated after the civil war. By looking at the communes in Kampong Speu that are most vulnerable to drought, this study aims to investigate the annual economic cost of drought on rice production in both rainfed and supplementary rice ecosystems and to do a cost-benefit analysis of the renovation of the Kvet Reservoir in the Peang Lvea commune in the Odongk district of Kampong Speu province.

METHODS

In a rainfed paddy rice ecosystem, wet season paddy rice production usually runs from May to November. If there is good onset rainfall (i.e., if the rains arrive at the expected time in the expected amount), farmers cultivate a late-maturing variety,[1] which is the variety they have traditionally used. If there is less than average rainfall between May and July, they will cultivate an intermediate and/or early-maturing variety (Figure 1).

The rice variety most prone to drought is the late-maturing one, which can be affected in a number of ways. If a drought spell of more than two weeks occurs during August, the young seedlings will be damaged. When this happens, farmers have to restart their paddy production using intermediate or early-maturing varieties. If low rainfall distribution occurs throughout the cropping season, it results in a low yield. Finally, the cultivated area will be reduced if rainfall ceases prematurely before October.

Intermediate and early-maturing rice varieties are least prone to drought. Farmers cultivate these varieties during late August and September when the soil throughout the country is full of moisture. However, no matter the rice variety, the early cessation of rainfall will adversely affect the rainfed paddy ecosystem area (as shown in Table 1).

Costs of Drought

Wilhite and Glantz (1985) identify three kinds of impacts from drought, namely: economic, social, and environmental impacts, which correspond to loss, cost, and damage. Logar and van den Bergh (2012) examine the literature and find that there are three types of drought costs: direct, indirect, and non-market (intangible) costs. While Wilhite and Glantz categorize the kinds of drought impacts and link them with groups or individuals, Logar and van den Bergh monetize costs based on the order of impacts. For example, the direct cost of drought in agriculture is the reduction of crop production. In this study, the costs of drought, which are calculated at the household level, consist of (1) the interruption cost, as seen in the increase in labor and inputs; (2) yield reduction or low productivity cost, despite the additional labor and inputs; and (3) the damage cost, wherein the harvested area is smaller than the cultivated area.

The interruption cost is incurred when good onset rainfall is followed by a drought spell during the middle of wet season rice, thereby forcing farmers to increase their labor and inputs for their paddy rice production. In this cost category, farmers cultivate their paddy field twice but harvest only once. This cost, which covers the additional expenses for cultivation—ranging from preparing seedlings to transplanting—is usually ignored in the literature. However, the second type of costs, yield reduction caused by drought (i.e., water constraints throughout the cropping season), is often discussed in the literature, for example in Helmers and Jegillos (2004) and Ministry of Energy (2005). Lastly, the third type of cost is incurred when there is early rainfall cessation, which destroys the crops and reduces the size of the harvested area compared to the cultivated areas. These data are well recorded by local authorities and the province's Department of Agriculture.

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[1] The ten rice varieties promoted by the Royal Government of Cambodia since 2011 range from early-maturing to late maturing types. The three early-maturing varieties are: Sen Pidao, Chul'sa, and IR66; the four intermediate-maturing varieties are Phka Rumdoul, Khka Romeat, Phha Romdeng and Phka Chan Sen Sar; and the three late-maturing ones are Riang Chey, CAR4, and CAR6 .

Figure 1. Kampong Speu paddy rice crop calendar

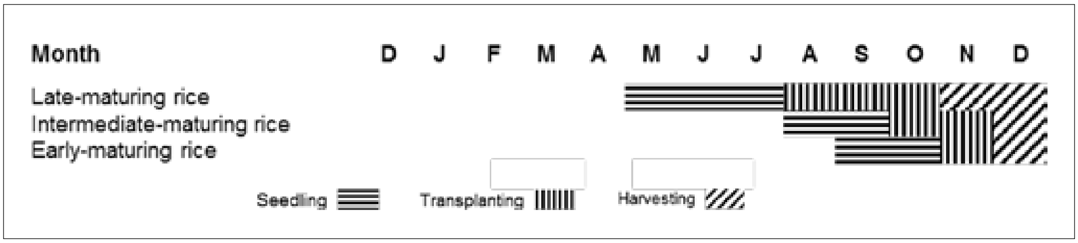

Table 1. Potential drought impact on rainfed rice ecosystems in Cambodia

Drought	Varieties	Seedling	Transplanting	Yield	Area-Harvest
Early-season	Late-maturing	Yes	Yes	Yes	Yes
Mid-season	Intermediate-maturing	No	No	Yes	Yes
Late-season	Early-maturing	No	No	Yes	Yes

The costs of drought for rainfed farmers can be estimated temporally depending on the nature of drought, that is, whether the drought occurs in the middle of the wet season rice production; or water constraints characterize the entire cropping season; or the rainy season ceases prematurely. If any of these events occur, the year is called a drought year.

Over the long term, the annual expected cost[2] (AEC) of drought to rainfed farmers is higher than that for supplementary-irrigated farmers (Equation 1). The costs of drought faced by farmers with access to supplementary irrigation can be estimated based on the indication of nature of drought from the rainfed location.

$$AEC = \begin{array}{l}\text{(annual probability of drought)} \\ \times \text{ (costs in drought year)}\end{array} \quad (1)$$

Assessing the Development Alternative

Chhinh and Poch (2012) conducted focus group discussions with local authorities to identify a number of drought adaptation options that would reduce the vulnerability of farmers to the changing climate in the rural areas of Kampong Speu. The most common method identified was securing water for paddy rice production through another water source such as a water reservoir, pumping machine, and/or a tube well. From their findings, they concluded that providing irrigation systems for farmers in rural Kampong Speu was necessary and urgently required.

In the case of normal temporal rainfall distribution, irrigation (for example, from water reservoirs) may not provide any benefits to paddy productivity as farmers are able to cultivate their crop according to the calendar[3]—

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[2] This is also referred to in the literature as expected costs avoided (ECA).

[3] Late-maturing varieties take six months, with sowing done in May/June and harvesting in November/December. Intermediate-maturing varieties take four months, with sowing in August/September and harvesting in November/December. Early-maturing varieties take three months: from May to July in the early wet season, and from January to March in the late wet season. The vulnerability index ranges from 0 to 1. Taking an index of 0.5 as the threshold, a commune with a vulnerability index higher than 0.5 is considered vulnerable.

the rice plant grows normally until harvest time and the crop yields are as expected. However, due to natural hazards caused by climate change effects, farmers, especially those who depend on rainfed rice production, are no longer able to rely on normal temporal rainfall distribution and must adapt their farming methods and materials to changes in the weather. If there is late onset or lower amounts of rainfall during the starting period of the cropping season, farmers must either delay their crop calendar or transplant the seedlings to their paddy field without water and hope that rain falls in the following days, risking the destruction of the new plants. Many farmers in Cambodia report having experienced these conditions (Chhinh and Poch 2012). Therefore, water reservoirs can play a very significant role in providing supplemental water during the growing period when there are inadequate amounts of rainfall. The water reservoir thus allows for the avoidance of costs associated with drought and enables farmers to start their cropping season according to the time required by the preferred rice variety.

Currently, if supplemental water is needed in rice fields where there are no irrigation systems, water is pumped from nearby small ponds and underground water sources. This practice, however, cannot alleviate severe and widespread drought because the area of paddy that can be watered is relatively small in scale. On the other hand, the reservoir, as a supplemental water source, will generate benefits for local communities during the dry season, especially for domestic usage in rural Cambodia (i.e., home gardening, double cropping, aquaculture, and livestock raising). It may also provide indirect benefits such as improving sanitation.

In assessing the benefits of using reservoirs to mitigate drought, the costs of drought should be compared as follows: (1) between rainfed and supplementary irrigated rice systems, and (2) between a drought and non-drought year (see Callaway 2003 for such a climate risk assessment framework).

Costs and Benefits Analysis

An extended discussion of the costs and benefits analysis (CBA) economic framework can be found in many textbooks (Layard 1972; Mishan 2007). The benefits of using a CBA here, particularly in relation to risk-based studies, are outlined by Mechler (2005), who identifies the following principles of CBA: (1) a ‘with’ and ‘without’ approach, (2) a focus on the selection of ‘best option’ if there is more than one option, (3) a societal point of view, and (4) clearly-defined boundaries of analysis. A CBA, however, becomes more complex once social and environmental issues are incorporated.

Using the ‘with’ and ‘without’ approach, it is possible to compare an investment project, for instance, with no water reservoir and one with a water reservoir in a community. Since the costs of construction are incurred during the first few years, and the operation and maintenance during the lifetime of the reservoir and the benefits from the reservoir are distributed into the future, they can be calculated at present value (PV) (Equation 2) and net present value (NPV) (Equation 3).

$$PV\ (X) = X_t \frac{1}{(1+r)^t} \tag{2}$$

$$NPV = \sum_{t=0}^{T} B_t(1+r)^{-t} - \sum_{t=0}^{T} C_t(1+r)^{-t} \tag{3}$$

where X is the present value of costs (C) or benefits (B) at time (t) at the discount rate (r). The project starts from year one (t=0).

One of the benefits of CBA is that it is used widely as a decision-making tool by many organizations including the World Bank, by government agencies, and private investors. The traditional criteria for evaluation include the NPV, the benefits and costs ratio (BCR), and the rate of return. However, care must be taken when choosing a discount rate, as is extensively discussed in the Stern Review (Dietz 2008; Nordhaus 2007), as well as in considering uncertainty and other aspects such as equity.

The study compares the NPV of two development scenarios (with and without) over a period of 20 years (based on the life span of a water reservoir). The 'with' scenario refers to farm households who have access to supplemented irrigation. We examined two time periods, a drought and a non-drought year, and requested respondents to recall the costs of rice production associated with drought episodes. Two communes representing two rice ecosystems were selected for comparison: the Sopoar Tep commune served as the supplementary-irrigation site and the Peang Lvea commune served as the totally rainfed site. A household questionnaire was used to obtain information and understand household characteristics.

Sample Selection

Chann and Kong (2014) has developed an index that measures the degree of vulnerability in agriculture. With a vulnerability index of 0.53, the Peang Lvea commune is highly vulnerable, while Sopoar Tep is moderately vulnerable with a vulnerability index of 0.44.[4] The main reason for the difference in the degree of vulnerability is because of Peang Lvea's frequent exposure to drought and its low adaptive capacity to this problem, especially given its smaller irrigated paddy rice areas. With access to irrigation, the Sopoar Tep commune can produce rice twice per calendar year, compared to once per year in Peang Lvea. The average paddy rice yield in Sopoar Tep is 2.5 tons per hectare, compared to only 1.5 in Peang Lvea. Both communes depend mainly on agriculture, with 76.4 percent of households in Sopoar Tep and 99.2 percent in Peang Lvea working as farmers.

Purposive and random sampling methods were employed to select the study sample. About 400 households from the total populations of the Peang Lvea and Sopoar Tep communes representing two rice ecosystems (one totally dependent on rainfall, and the other one with access to supplementary irrigation) in Kampong Speu were selected to be part of the survey. A total of 200 households were chosen from each ecosystem at the selected study sites. All enumerators were trained by the research team before conducting actual fieldwork to strengthen the quality of the collected data.

RESULTS

The household survey results show that the respondents in the Peang Lvea commune hold 209 hectares of land collectively, while the total cultivated land for 200 respondents in the Sopoar Tep commune is 129.1 hectares. Farmers in Sopoar Tep have access to supplementary irrigation while those in Peang Lvea depend on rainfed cultivation. It is important to note that the supplementary irrigation, which allows farmers to combat the effects of drought in both wet-season and dry-season rice production, also allows farmers to have two crops every year.

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[4] The exchange rates used in this study is 1 USD = KHR 4000 riels.

Production Costs in Both Rice Ecosystems

The production cost is generated from the four stages of rice production: seedling, transplanting, post-transplanting or pre-harvesting, and harvesting. The seedling stage covers preparing the land, purchasing rice seeds, sowing rice seeds, and pulling seedlings. Transplanting covers the labor cost of transplanting and some inputs such as fuel, cost of pumped water, and fertilizers. The growing stage covers the application of some inputs such as fertilizers, pesticides, pumped water, and labor. Lastly, harvesting covers the labor cost for harvesting and transportation.

The calculation of inputs and labor in the two rice ecosystems uses constant prices in both non-drought years and drought years. Notably, the labor cost in both communes will be the same. For example, four hours of labor costs KHR 10,000 per person (about USD 2.5).[5] To generate the total production cost, the labor contributed by each household (own labor) is also included. Farmers in Peang Lvea employ only their family members as labor in the four stages of rice production. If own labor[6] is not included in the calculations, the production cost in Peang Lvea is far below the production cost in Sopoar Tep.

Remarkably, almost all farmers in Peang Lvea use traditional tools for cultivation; for example, they use cattle to plow the land and manually harvest the products. Farmers in Peang Lvea believe that if they employ machines for cultivation (such as hand tractors and harvesting machines), they will lose 40 percent of their output to cover the cost of the new technology. Unlike farmers in Peang Lvea, farmers in Sopoar Tep employ technology for their rice production, especially harvesting machines. That is why the productivity in Peang Lvea is much lower than in Sopoar Tep.

It was found that among the four stages of rice production, the only stage wherein farmers in Peang Lvea invest more than those in Sopoar Tep is the transplanting stage. This is for two reasons. First, most of the farmers in Peang Lvea plow their land twice before transplanting, and second, almost all farmers in Peang Lvea use their own labor to complete farming activities while farmers in Sopoar Tep invest in technology. In general, farmers in Peang Lvea invest less input than farmers in Sopoar Tep. Farmers in Peang Lvea spend KHR 188,500 (USD 47.12) on fertilizers only (not including pesticides) while farmers in Sopoar Tep invest KHR 642,857 (USD 160.71) on both fertilizers and pesticides. In short, it can be said that farmers in Peang Lvea invest in own labor more than Sopoar Tep, while farmers in Sopoar Tep invest more on fertilizers and pesticides than farmers in Peang Lvea.

Impact of Drought

The different types of costs incurred by rainfed farmers due to drought can be estimated temporally. These costs, which arise depending on the nature of the drought are: interruption cost, when there is early cessation of rainfall; low productivity cost, when drought occurs in the middle of planting wet-season rice; and damage cost, when there are water constraints throughout the cropping season.

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[5] Own labor is calculated by multiplying the hours worked by the market price (KHR 2,500 per hour or KHR 10,000 for four hours).

[6] For more technical details, see Mechler (2005).

Interruption costs

There are two possible stages where the rice production process can be interrupted: the seedling and transplanting stages. Each household usually prepares its own seedbed and cultivation seedlings for paddy rice cultivation. The likelihood of interruption costs was higher in rainfed communities than in supplementary-irrigated ecosystems. For instance, 52 percent and 35.5 percent of respondents in Peang Lvea experienced the effects of drought during the seedling and transplanting stages, respectively, while only 8.5 and 5 percent of respondents in Sopoar Tep felt the impact of drought during seedling and transplanting, respectively. Therefore, in both communes, a greater number of farmers reported adverse effects in the seedling than in the transplanting stage. This shows that the likelihood of damage is greater in the initial stage.

Farmers found it difficult to recall the number of times they experienced losses during the seedling and transplanting stages of their rice production. There was a general agreement, though, that the damage from drought recurred every four or five years.

Low productivity costs

Low productivities were reported more in rainfed areas (85% of households in Peang Lvea) than in supplementary-irrigated areas (24% of households in Sopoar Tep). In the rainfed area, farmers normally have a yield of approximately 1.5 tons per hectare, compared to around 3 tons per hectare in supplementary-irrigated areas. However, in 2012, the yield was 1.40 and 3.01 tons per hectare in Peang Lvea and Sopoar Tep, respectively. The yield reduction due to a drought episode was reported to be about 30 percent in Peang Lvea and 35 percent in Sopoar Tep, based on the household survey. The recurrent period of low yield was reported to be 10 years.

Damage costs

The total area of cultivation during both normal and drought years is 338.1 hectares (209 and 129.1 hectares in the Peang Lvea and Sopoar Tep communes, respectively). This means that farmers always cultivate their land regardless of whether it is a normal or drought year. However, each commune faced a reduction in the area harvested during drought years, that is, from 209 hectares to 57.6 hectares in Peang Lvea (an 83% reduction) and from 129.1 to 123.3 hectares in Sopoar Tep (a 5% reduction). There is a sizeable decline in the area harvested during a drought episode in a rainfed area.

The loss of harvested area in Peang Lvea during a drought year was 72 percent and 82 percent of total production (241.1 tons) compared to Sopoar Tep's 4.5 percent of harvested area and 20 percent (66.7 tons) of total production. It was reported that farmers experienced this loss in 2004 and remember it occurring once during the last 20 years (1990–2010).

Expected Loss to Farmers in Rainfed Areas

The total expected loss from drought during the period 1991–2010 is estimated in this and the following section.[7] The damage costs are estimated based on the premise that there is damage during the seedling and transplanting stages once every five years, yield reduction once every 10 years, and paddy damage once every 20 years. The premise was set based on key informant interviews in the study sites.

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[7] There is a separate report that contains the feasibility study for the Kvet Reservoir.

In a normal year, the cost of the seedling stage is USD 23,869 (or USD 114.21 per hectare) and the cost of transplanting is USD 46,807 (or USD 223.96 per hectare). Some 52 percent of households in Peang Lvea reported that they had experienced damage during the seedling stage and 35.5 percent reported damage during transplanting. Assuming that these figures also represent the total increase in production costs (borne out of the farmers' need to re-prepare their seedlings and to transplant), the cost increases to USD 12,411.88 for the seedling stage and USD 16,616.49 for transplanting. Hence, in total, the cost in Peang Lvea from damage during the seedling and transplanting stages is USD 29,028.37 per 209 hectares in a drought year.

Based on normal yield (1.4 tons per hectare in 2012) of rainfed paddy rice, the total production in Peang Lvea is 292.60 tons which is equal to USD 80,465.00 (USD 275 per ton at farm gate at 2012 prices). During a drought episode, with 85 percent of households reported to experience a yield reduction of about 30 percent, the production will be 217.99 tons or equal to USD 59,946.43. The cost of yield reduction is USD 20,518.58 per 209 hectares in the drought year.

Finally, the damage to the harvest area is calculated at USD 66,368.50. The total harvested area during a severe drought year was 57.6 hectares, with a total production of 51.26 tons from the 209 hectares of the sample. During the drought episode, farmers could only earn USD 14,096.50, while in the non-drought year farmers could produce up to USD 80,465 (based on a yield in 2012 of 1.40 tons per hectare).

The expected loss from drought in the Peang Lvea commune is USD 11,175.96 per annum per 209 hectares (Table 2). This is based on a recurrent period of different drought intensities that are associated with damage in the seedling and transplanting stages, yield reduction, and reduction in harvested area. The cost of each category is similar in terms of loss-frequency function. The expected loss is USD 53.47 per hectare.

Expected Loss for Farmers in Supplementary Irrigation Areas

This section presents the estimation results on the expected loss from drought during the period 1990–2010. As in the rainfed areas, the damage costs are estimated based on the fact that there is damage to seedlings and transplanting once every five years, yield reduction once every 10 years, and paddy damage once every 20 years.

In the ST commune, the cost from damage suffered during the seedling and transplanting stages is USD 2,357.78 in a drought year per 129.1 hectares. In a normal year, the cost during the seedling stage is USD 14,177.76 (or USD 109.82 per hectare), and the transplanting cost is USD 23,053.39 (or USD 178.57 per hectare). Some 8.5 percent of households in ST

Table 2. Costs of drought and benefits of forgone with/without development alternative

Revenue	Net Revenue (USD per Hectare)		
	Non-drought Year	Drought Year	Drought Costs
Rainfed	350	100	250
Supplementary irrigation	550	450	100
With/without	200	350	-

Source: Modified from Callaway (2003)

reported that they have experienced damage to seedlings and 5 percent reported damage during the transplanting. Assuming that these figures also represent the total increase in production costs (as farmers re-prepare their seedlings and transplant), the cost increases are USD 1,205.11 for the seedling stage and USD 1,152.67 for transplanting.

The cost due to yield reduction is USD 9,031.00 per 129.1 hectares in a drought year. Based on normal yield in supplementary irrigated paddy rice (3.01 tons per hectare in 2012), the total production in ST is 388.59 tons, which is equal to USD 106,862.25 (USD 275 per ton at farm gate in 2012 price). During a drought episode, 24 percent of households reported that they experienced yield reduction (about 35 percent less than in a normal year). Therefore, production will be 355.67 tons due to yield reduction, which is equal to USD 97,831.25.

Finally, the cost of the damage to the harvest area is USD 31,924.75. The total harvested area during the severe drought year was 123.30 hectares (a reduction from 129.1 hectares) with a total production of 272.2 tons. During a drought episode, farmers could only produce USD 74,937.50 worth of rice, while the normal-year farmers could produce up to USD 106,862.25 worth.

In the ST commune, the expected loss from drought in supplementary irrigated paddy production is USD 2,970.90 per annum per 129.1 hectares. This is based on a recurrent period of different drought intensity levels that are associated with the damage of seedlings and transplanting, yield reduction, and damage to harvested areas. As shown in Table 3, the cost of yield reduction is higher than the rest in terms of loss-frequency function. The expected loss is about USD 23.01 per hectare.

The difference in expected loss per hectare from drought events in rainfed (USD 53.47) and supplementary irrigated (USD 23.01) areas is USD 30.46.The difference in expected loss is relatively large because PL is more sensitive to changing rainfall and therefore experiences a greater loss in production than ST. Also, there is a big difference in the productivity levels of rainfed and supplementary irrigated areas. For example, ST yields twice as much as PL. Also, PL and ST are affected differently by drought in terms of the reduction in the harvested area.

Water Reservoir Feasibility Study

Cost analysis of the Kvet reservoir renovation

Attempts have been made to supply farmers in the Kampong Speu province with water, especially in the Peang Lvea commune. This study investigated the cost of renovating the Kvet reservoir, an old reservoir built during 1975–1979 in the Peang Lvea commune. Portions of the reservoir are currently being used to cultivate rice. The land surrounding it is barren and has been set aside for restoration.

Based on our feasibility study, the primary costs of the rehabilitation of the reservoir include renovating the 1,150-meter dike, renovating the 4,000-meter canal, removing and reconstructing one large water gate, and constructing culverts with gates.[8] The water is supplied to paddy rice using gravity. The total engineering cost is USD 343,680.

It is estimated that USD 21,204 will be spent annually for operation and management (USD 36 per hectare). To increase the skills of farmers in PL to be on par with those in ST, agricultural extension services will be provided to them at the cost of USD 26.40 per hectare or USD 15,547 in total.

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[8] This value (USD 7,455.24) is from 324 hectares × USD 23.01 (expected drought damage costs in ST).

Table 3. Drought-risk as represented by the loss-frequency function of rainfed agriculture

Recurrent Period (years)	Annual Probability	Damage (USD)	Risk: Prob × Damage (USD)
5	0.2	29,028.37	5,805.67
10	0.1	20,518.58	2,051.86
20	0.05	66,368.50	3,318.43
		Annual expected damage	11,175.96

Additionally, the renovation of the Kvet reservoir will result in a loss to the farmers who currently cultivate their paddy rice in the water reservoir. According to the engineering study, 49.56 hectares of public land would no longer be available for cultivation after the renovation. Assuming that 49.56 hectares could produce 1.40 tons of rice per hectare, the total production in the current cultivated land in the reservoir is USD 19,081 annually.

In sum, the total cost of renovating the Kvet reservoir comprises the engineering cost of renovation, the operation and maintenance cost, the agricultural extension service, and the opportunity cost of the cultivated land in reservoir. Specifically, the cost in year 0 is USD 362,761, while the cost in years 1 to 19 is USD 36,751 per year.

Benefit analysis of the renovation of the Kvet reservoir

According to our feasibility study, the Kvet reservoir could supply water to 324 hectares of cultivated land in the wet season, 75 hectares in the dry season, and 190 hectares in early season rice production. The 324 hectares include the 209 hectares of the paddy fields owned by households which participated in the survey.

If there is a water reservoir in Peang Lvea, the expected loss during drought events of the Sopoar Tep commune is transferred to the estimated expected loss against the whole area (324 hectares), meaning that if the 324 hectares of paddy area of PL is irrigated like in ST, farmers will lose only USD 7,455.24 instead of USD 17,324.28[9] instead of USD 17,326.8 (or a difference in amount of USD 9,850.23. This value is then treated as the avoided damage cost that is provided by the facility. At the same time, the productivity of the wet season is expected to increase from 1.40 to 3.01 tons. The net revenue of wet season rice will increase by USD 392.59 (from USD –361.33 in Peang Lvea to USD 31.26 per hectare in Sopoar Tep for 324 hectares of wet-season rice), which comes up to about USD 127,199.16 per 324 hectares of irrigated land.

The feasibility study finds that the reservoir can supply 75 hectares of dry-season rice and 190 hectares of early-season rice, with the additional areas also estimated as part of the feasibility study. This assumes that even during a drought year, there will be no impact on dry-season and early-season rice, and the net revenue is the same as ST in dry-season rice and wet-season rice (USD 70.18 and USD 31.26 per hectare, respectively). Therefore, the dry-season rice and early-season rice production will enable farmers to gain USD 5,263.50 and USD 5,939.40, respectively.

To summarize, the total benefit of the project is USD 148,271 per year, including

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[9] This value (USD 17,324.28) is from 324 hectares × USD 53.47 (expected drought damage costs in PL).

avoided damage cost, increased productivity, and the benefit of dry-season rice and early-season rice. This benefit would occur from year 1 to year 19.

Benefit-cost analysis and sensitivity analysis

With the rehabilitation projected to begin in 2014, the reservoir should be functional and therefore start yielding benefits from 2015. The projected costs include USD 362,761 in Year 0 (to cover the first year of construction and the opportunity cost of cultivated land in the reservoir) and USD 36,751 from Year 1 onward (to cover operation and maintenance, agricultural extension service, and the opportunity cost of cultivated land in the reservoir). The benefits, yielded from the first year, are the avoided damage costs based on annual expected damage and the increasing yield from supplementary irrigation and double cropping. The total benefit is USD 148,271. In order to complete the CBA and sensitivity analysis, four scenarios are generated: a good scenario (Scenario 1), a bad scenario (Scenario 2), a worse scenario (Scenario 3), and the worst scenario (Scenario 4).

A good scenario is generated with the assumption that the project is under perfect estimation. In other words, there is no change from the analysis. As shown in Table 4, in this scenario the project generates USD 914,834.94 as net present value for 20 years, where the benefits are higher than costs 2.18 times. Figure 2 also illustrates that even when the discount rate increases to 14 percent, the project could generate USD 376,000 over 20 years.

A bad scenario (Scenario 2) is formulated by assuming that the project cost is underestimated by 15 percent or that the project cost could increase by 15 percent of the total cost of the project. Under this scenario, the project only earns USD 798,910.00 as net present value and has a benefit 1.9 times higher than cost with an internal rate of return (IRR) of 25.13 percent. If the discount rate increases to 14 percent, the project could earn USD 285,000 (Figure 2).

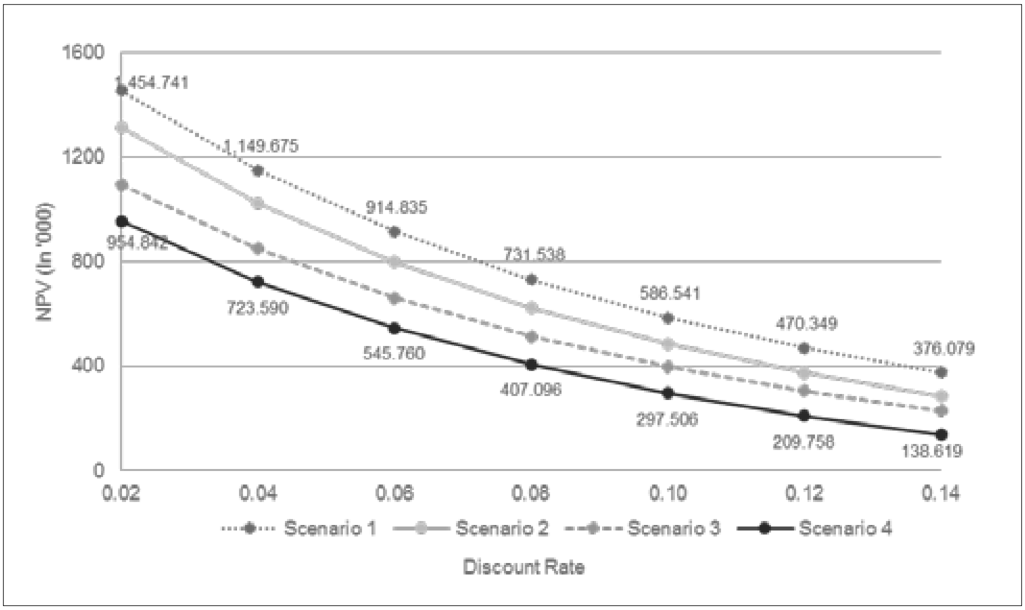
The worse scenario (Scenario 3) results from the assumption that drought would destroy 15 percent of the total benefit. If cost is constant but 15 percent of the benefit is reduced by drought, the project could earn USD 661,684.76. Therefore, the project could get 24.30 percent of IRR with a benefit 1.86 times higher than cost. In case the discount rate increases to 15 percent, the project will still manage to generate USD 229,000.

Finally, with the worst-case scenario (Scenario 4), it is assumed that the project underestimates 14 percent of the cost, and that 15 percent of benefits are decreased by drought. Even in the worst case, the project does not lose under the discount rate of 6 percent. In this scenario, the project could earn USD 545,759.82, with the benefits 1.61 times higher than the cost, and its IRR is 19.53 percent. Although, under the worst scenario

Table 4. Drought-risk as represented by the loss-frequency function of supplementary irrigation agriculture

Recurrent Period (years)	Annual Probability	Damage (USD)	Risk: Prob × Damage (USD)
5	0.20	2,357.78	471.56
10	0.10	9,031.00	903.10
20	0.05	31,924.75	1,596.24
Annual expected damages			2,970.90

Figure 2. Sensitivity analysis of the Kvet Reservoir project



the discount rate decreases to 14 percent, the project still provides benefits. Under a discount rate of 14 percent in the worst scenario, the project could earn USD 138,000.

Assuming the discount rate of 6 percent is correct and the benefit is constant, the profit is still positive if the cost is underestimated by less than 15 percent. If the cost of project is constant with a 6 percent discount rate, the project is still beneficial if the benefit decreases by less than 15 percent. In all scenarios, the project provides benefits for paddy rice cultivation.

DISCUSSION

The *Stern Review* estimates that the annual cost from climate change impacts is approximately 5 percent of the world's GDP, and, in the worst cases, the damage cost could jump to 20 percent or more (Stern 2006). This study finds that the expected loss to a rainfed farmer during a drought year is USD 53.48 per hectare. At a 6 percent discount rate, the rehabilitation of the Kvet Reservoir will yield a net present value of USD 914,834.94 (Table 5). Also, its benefit-cost ratio of 2.18 is high. Rehabilitating the reservoir will help to provide water and food security for smallholder farmers in rural Cambodia, and is the most effective project proposed to date. For example, a study by Barker and Molle (2004) found that the trend of benefit-cost ratio of irrigation investment in the Philippines and Sri Lanka diminished between the 1970s and the 1990s from the highest number (more than 3.5) to the lowest number towards the end of the study period (less than 0.5). The benefits calculated in Table 5 do not take into account other incidental benefits, such as protecting non-rice crops such as watermelon.

In the rural livelihood context of Cambodia, irrigation is often viewed as providing water security and is closely linked with food security, the cost-benefit analysis on irrigation in this paper primarily focuses on profits, especially measurable ones. While the latter perspective produces quantitative values that are useful

Table 5. Calculation of the costs and benefits of the rehabilitation project

BCA	Scenario 1	Scenario 2	Scenario 3	Scenario 4
NPV	914,834.94	798,910.00	661,684.76	545,759.82
BCR	2.18	1.90	1.86	1.61
IRR	30.60%	25.13%	24.30%	19.54%

for policy makers (which they often prefer), the former viewpoint highlights social welfare and, more importantly, the survival of the rural, small-size paddy farmers who are highly dependent on subsistence farming.

By default, farmers will do everything in their capacity to maintain their yield, and while rice yield declines may not be recorded, the cost of operating their farms increases during all intensities of drought. Therefore, the observed yield fluctuation may not be associated with drought (rainfall) but may be related to other factors such as lack of labor, an increase in the price of fertilizers (which may also happen during years with good rainfall), and a resultant decline in yield. Thus, since drought is a creeping phenomenon which is often hard to identify, in the event of drought, the hardship experienced by farmers is increased before any interventions occurs.

CONCLUSION

In Cambodia, the biggest concerns resulting from climate change impacts are flood and drought. Drought occurs frequently in Cambodia and its impact is felt by many, especially the rainfed farmers in the Kampong Speu province whose livelihood is heavily dependent on agriculture. Recognizing that agriculture is the backbone of the economic sector, the Royal Government of Cambodia is implementing methods to mitigate drought, especially through improvements in physical infrastructure such as installing water reservoirs. Within the government's climate change projects, there are nine projects aimed at mitigating drought and five projects to mitigate the effects of flood. All of the drought projects are focused on irrigation, such as water reservoirs.

Households in Kampong Speu often experience drought. Rainfed farmers are highly vulnerable to climate variability and interventions are necessary and urgently required, especially in relation to agriculture. It is socially and scientifically agreed that Cambodia will experience more drought in the future; therefore securing water is vital to avoid widespread crop failure and the resultant hardship and poverty.

This study found that farmers experienced drought one to four times between 1990 and 2012. Drought was defined based on the farmers' experiences of water shortages in their paddy fields resulting in damage to seedlings, yield reduction, or the destruction of paddy rice. The degree of severity of drought experienced was different for farmers located within the range of supplementary irrigation to those who were totally reliant on rainfall, with both the drought-recurrent period and the degree of impacts from drought higher in the rainfed paddy rice area. Without supplementary irrigation, data suggested that there was a reduction of at least 73 percent of paddy production compared to a non-drought year. It was estimated that farmers in rainfed areas faced an annual expected loss of USD 53.48 per year for every hectare of paddy field.

After conducting a feasibility study of the Kvet Reservoir (an unused reservoir located in the Peang Lvea commune), we found that the costs of the investment on rehabilitation are low compared to the benefits. If rehabilitated, the reservoir will play a very significant role in food security, as the majority of households in the Peang Lvea commune are subsistence farmers who own very small areas of land. One season of crop failure spells long-term disaster for many households. Therefore, it is imperative that the rehabilitation of the reservoir be started as soon as possible before irreversible consequences happen in the community.

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