



**វិទ្យាស្ថានសភាកម្ពុជា**  
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## RESEARCH PAPER

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# Current Impacts of Climate Change on Water Resources in Cambodia: Challenges from Floods and Droughts

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## 1. Introduction

Climate change can be defined as a statistical change of temperature, precipitation, wind, rainfall, and sea level that continues for a long period of time, resulting from natural processes<sup>i</sup> such as planet atmosphere or earth atmosphere.[1, P-8, 2] These processes may cause land use and anthropogenic<sup>ii</sup> changes in the atmosphere.[2] Climate change is also defined as the varying rainfall patterns affecting different aspects of agriculture, especially in terms of lower crop yields.[3, P-1]

Climate Change has become a worldwide concern [4, P-1] because it impacts global sustainability, including water resources, and this affects many aspects of human and economic activities (e.g., agriculture). [5, P-1]

Currently, climate change and its impacts on water resources have also been observed in Cambodia, a rain-fed, agriculture-dependent country. It has affected water resources which have, in turn, impacted agriculture, [5, P-1] mostly through natural disasters, during the last few decades. Even though the Cambodian government has established strategies to deal with the concerns, several issues remain, including water distribution for agriculture and the impacts of natural disasters, such as flood and drought, on arable land for growing rice crops, and livelihoods.

Cambodia is at the center of the Mekong River system within the Mekong River basin, and water resource management has a trans-boundary dimension. Some important watersheds within Cambodia have been seriously degraded[5, P-2] due to climate change in relation to the seasonal distribution of rainfall, with more intense floods in the rainy seasons and droughts in the dry seasons. A marginal decrease in dry-season rainfall and an increased volume of rainy-season rainfall can result in increased droughts and floods.[5, P-2]

The main challenges are water distribution and the availability of water throughout the seasons, regions and among users. Cambodia's water distribution patterns have changed dramatically, with flooding and high water levels in the rainy season and with water shortages and parched soil in the dry season.[5, P-2]

### Research Objectives

Based on the issues mentioned above, this study aims to achieve three objectives:

- To review the current status of water resources in Cambodia;
- To explore the impacts of climate change on water resources and the challenges caused by floods and droughts;
- To review the water management for climate resilience policy of Cambodia, and remaining challenges in the face of climate change.

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<sup>i</sup> "The United Nations Framework Convention on Climate Change". 21 March 1994. *Climate change means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.*

<sup>ii</sup> *Anthropogenic: Related to or resulting from the influence of human beings on nature.*

## Research Questions

To achieve the objectives, the study's objectives is to answer the following questions:

- What are the impacts of climate change on water resources?
- What are the impacts of climate change related to water resources (in the context of floods and droughts) arable land, infrastructure, housing, and human lives?
- What are the government policies regarding water resource management and climate change adaptation strategies?

This study uses literature reviews of governmental documents, official statistics, and existing studies.

## 2. The Current Status of Water Resources in Cambodia

### 2.1 Water Distribution

Cambodia is located on the south-western part of the Indochina Peninsula, between 10° to 15° north latitude and from 120° to 108° east longitude, bordering three countries; Thailand to the west and north, Lao PDR to the north, Vietnam to the east and south, and the Gulf of Thailand to the southwest.[6, P-47-48] The country has large main water features; the Tonle Sap River and Lake, the Bassac River, and the Mekong River systems flowing from north to south.[1] These water features, covering three quarters of the country, are divided into three geographical zones: (1) the southwest and western zone has the Elephant Mountains and the Cardamom Mountains; (2) the north adjoins the Korat Plateau of Thailand to the Dangrek Mountain; and (3) the northeast zone has the plateau of Ratanakiri and the Chhlong Highlands to the east, merging with the Vietnam Central Highland.[1, P-9]

In Cambodia, there are two types of water resources: [1, P-7] annually, there are approximately 17,600 million cubic meters of aquifer groundwater; and 75,000 million cubic meters of surface water from runoff.[1, P-7] Water has a very important role in agriculture, industry, household use, navigation (waterway traffic), tourism and hydropower. The largest amount of the water used each year is estimated to be around 750 million cubic meters (10 percent of the country's total available water), of which 95 percent (710 million cubic meters) is used for irrigation in agricultural production.[1, P-7]

In urban areas, 76 percent of the people have access to safe water; however, the figure is only around 42 percent in respect of people living in rural areas. [7, P-11] Water is used more in the other sectors (such as agriculture) compared with domestic use. Furthermore, some urban areas lack water in the dry season.[7, P-11]

Using irrigation for agriculture would only be economically reasonable in the Tonle Sap Basin and the Mekong lowlands, where ground elevations are below 30-35 meters above mean sea level.[7, P-11] These areas do not have enough reservoir capacity to supply all the water needs in the dry season. Additionally, the infrastructure of the country was destroyed during the period of civil war (during the 1980s), and approximately 250 irrigation systems had to be rehabilitated and/or constructed between 1999 and 2006 to support land areas of around 720,000 hectares (approximately 32 percent of the rice cultivation area).[7, P-12] The Ministry of Industry, Mines

and Energy (MIME) reported that there were two hydropower development plants in 2008, with a capacity of 13 megawatts (MW), and MIME has planned to develop 2,000-4,800 MW of hydropower installations by 2020.[7, P-12]

Another issue relating to water resources is the increasing development of hydro power, which can have significant impacts such as the displacement of housing and resettling of people into new areas, flooding resulting from impoundment (i.e., the creation of a reservoir) of water in front of the dam, and the removal of land (caused by the build-up of water behind the dam and from the release of water below the dam) used in farming and forests that provide the population with economic benefits.[7, P-12]

## **2.2 Water Management**

It is likely that climate change will increase the challenges related to water management. For example, less rainfall is anticipated during the dry season and more during the rainy season, with more extreme weather events and potentially worse seasonal water shortages and floods. Challenges are more serious for a developing country like Cambodia, where meteorological systems are not yet able to forecast extreme weather, as well as unpredicted droughts and flash floods, that have been a frequent occurrence.[1]

With regard to the management of water, the government body, the Cambodia National Mekong Committee (CNMC), is a high-level committee working as Cambodia's representative on the Mekong River Commission (MRC) Council and together with other representatives from line Ministries collaborating with other countries in the Mekong Basin. CNMC's main function is inter-ministerial coordination of water resources management. [7, P-20-21] There are eight organizations/agencies involved in this committee including, the Ministry of Water Resources and Meteorology (MoWRAM), the Phnom Penh Water Supply Authority (the Ministry of Public Works and Transport), provincial governments, and municipalities and development committees. They have developed strategic plans, drafted water legislation and regulations, monitoring policies and water resource management strategies and mitigation plans for water related disasters in the country.[7, P-20-21]

Basically, MoWRAM is the main actor managing and controlling flood and drought meteorology and hydrology.[7, P-25] It also manages and implements the present laws. MoWRAM cooperates with all relevant stakeholders (government and non-government) and other countries in the region[7] in addressing issues relating to floods and droughts.

## **3. Climate Change and Water Resources**

### **3.1 Overview of Climate Trends in Cambodia: Current and Future Forecasts**

#### **- Temperature**

Cambodia has experienced an increase in average temperature of 0.8°C since 1960, a rate of about 0.18°C per decade. The rate of increase is faster in the dry seasons, at 0.20-0.23°C per decade, and slower in the wet seasons, at a rate of 0.13-0.16°C per decade. The duration of hot days and nights

has become more prolonged since the 1960s with the average number of hot days per year between 1960 and 2003, rising by 46, an additional 12.6 percent of days. [8, P-1]

It is forecasted that the average temperature of Cambodia will increase by 0.7 to 2.7°C by 2060, and 1.4 to 4.3°C by 2090. The forecasts also show that the number of hot days will increase by 14-49 percent by 2060, and 20-68 percent by 2090. Days considered hot in Cambodia are projected to increase more quickly (rising by 29-96 percent) in the summer by 2090.[8, P-3]

#### - **Precipitation**

The forecasts for rainfall indicate an annual increase for Cambodia with the projected rise in wet season rainfall ranging from -11 to +31 percent by the 2090s. Moreover, the total rainfall during heavy events is forecasted to intensify by an additional 0 to 14 percent by the 2090s, with a predicted increase of 1 and 5-day rainfall of up to 54 and 84 millimeters, respectively, by the 2090s.[8, P-5]

### ***3.2 Impacts of Climate Change on Water Resources: Challenges from Natural Disasters***

There are several effects of climate change on water resources in Cambodia including impacts on the Mekong River's hydrological regime, fisheries and agriculture.[5, P-3] Furthermore, the seasons have changed whereby the dry season is longer and the rainy season is shorter, together with an increase of rainfall and floods in the rainy season, and a decrease of rainfall in the dry season. Simultaneously, in the dry season, the water flow of the Mekong River as well as its tributaries is reduced while it is increased in the rainy season. These effects are expected to create more frequent, serious and extreme natural disaster events, particularly floods, droughts and heavy storms. Drought will constitute the highest risk for agriculture in some areas in Cambodia in the future.[5, P-3]

Cambodia is likely to be one of the countries most frequently affected by natural disasters such as droughts and floods in Southeast Asia.[9, P-6] Because Cambodia's different regions are exposed to one or more of the natural disasters, the country is likely to experience significant damage. In addition, it is vulnerable to climate change and to changes in water distribution because it is an agricultural country, with around 80 percent of the population living in rural areas. Moreover, Cambodia lacks adaptive and water resilience capacity and strategies, with poor infrastructure and limited institutions. In fact, droughts and floods have been recognized by the government as a leading factor in poverty, particularly between 1987 to 2007 when they were the major cause of economic loss and mortality.[9, P-6]

#### ***3.2.1 Floods***

The southwest monsoons last from mid-May until the end of October and account for approximately three-quarters of the country's annual rainfall. As a result, the water that flows along the Mekong River and its tributaries as well as in the Tonle Sap Lake may cause floods.[9, P-6] Floods affect some provinces, such as Kandal, Kompong Cham, Kratie, Prey Veng, Stung Treng, Svay Rieng, and Takeo, almost every year. For example, a flash flood in the tributaries affecting the Tonle Sap Lake between 2000 to 2002 resulted in 438 casualties and damage of around USD 205 million.[9, P-6] From 1998 to 2002, more than 70 percent of the rice production in Cambodia was destroyed by floods and another 20 percent was affected by droughts. It is estimated that floods kill approximately 100 people on average annually and cause damage to agriculture of approximately



USD100 to 170 million each year. Floods have more frequently affected infrastructure along the floodplains in the past few years.[9, P-6]

Table 1: Impact of Floods on Arable Rice Land in Cambodia, 2010-2016

Year	Affected Area (Hectare)	Damaged Area (Hectare)	Total Arable Rice Land (Hectare)	Percentage of Affected Area of the Total Rice Land	Percentage of Damaged Area of the Total Rice Land
2010	74,429	17,357	2,391,016	3.11	0.73
2011	416,314	267,184	2,496,569	16.68	10.70
2012	58,098	16,510	2,512,038	2.31	0.66
2013	369,687	127,634	2,567,723	14.40	4.97
2014	81,083	24,100	2,564,572	3.16	0.94
2015	NA	NA	NA	NA	NA
2016	27,031	6,542	2,599,586	1.03	0.25

Source: Ministry of Agriculture, Forestry and Fisheries, 2010-2016

Table 2: Impact of Flood on Rural Livelihoods in Cambodia

Year	Deaths	Injured	Damaged Houses	Victims	Evacuated
1996	169	2	3,289	1,357,295	0
1997	0	0	0	0	0
1998	0	0	0	0	0
1999	3	0	2	7,849	675
2000	347	725	7,244	3,305,582	80,599
2001	19	0	1,676	590,026	12,889
2002	11	0	1,373	960,321	89,204
2003	7	0	357	96,999	1,495
2004	2	3	0	8,430	1,648
2005	9	0	947	72,567	3,868
2006	15	1	824	807,202	1,292
2007	2	2	334	75,156	0
2008	4	0	0	43,601	1,686
2009	32	17	482	528,597	46,022
2010	11	5	94	141,748	7,418
2011	250	22	1,048	1,884,402	155,102
2012	26	0	241	54,909	5,060
2013	184	11	1,103	1,893,178	191,587
2014	40	1	5	329,272	35,577
2016	2	0	3,590	48,235	160
2017	17	0	8,703	61,323	7,634
<b>Total</b>	<b>1150</b>	<b>789</b>	<b>31,312</b>	<b>12,266,692</b>	<b>641,916</b>

Source: National Committee for Disaster Management, Cambodia

Table 1 shows the impact of floods on arable rice land from 2010 to 2016. In 2010, the damaged area was less than 1 percent of the country's total rice fields, but increased to 10.7 percent as a

result of the flood in 2011. However, the rice fields damaged by floods decreased to less than 1 percent in 2012.<sup>iii</sup>

Table 2 shows the impact of floods on human lives and housing from 1996 to 2017. The figures for 2000, 2011 and 2013 show the high number of damaged houses, deaths and victims. While the floods in 2011 and 2013 resulted in heavy impacts on rice fields, they also had a significant effect on housing and human life.

In addition to the impact on human life and housing, floods also cause damage to infrastructure. For example, floods in 2013 damaged a total of 440 km of city, provincial and national roads and 18 bridges, 40 pipe culverts and 6 box culverts along national roads, as shown in Table 3. The impact on rural areas was even more severe as the flood damaged 555 bridges and drainage structures and 1,557 km of rural roads.

Table 3: Summary of the Main Damage Caused to Rural Roads by the 2013 Floods

Road Classification	Length(Km)	Bridges(Number)	Management Authority
	Total Damaged	Total Damaged	
National Roads	64.7	Bridges-18 locations Pipe Culverts-40 locations Box Culverts-6 locations  Total- 64 locations	Ministry of Public Works and Transport (MoPWT)
Provincial Roads	310		
City Roads	65		
Rural Roads	1,557	Bridges- 28 locations Pipe Culverts-404 locations Box Culverts-115 locations Spillways -8 locations  Total - 555 locations	Ministry of Rural Development (MRD)

Source: Post-Flood Early Recovery Needs Assessment Report

### 3.2.2 Droughts

Due to the fact that the management of water resources is limited, including the access to, and storage of, existing water resources, and the change in rainfall patterns (the delay in, or early finish of, the monsoon rains), droughts occur in Cambodia, especially in the province of Svay Rieng.[9, P-6] Drought impacts the country's economy due to crop failure, environmental damage and health problems. For example, during the period 1998 to 2002, 20 percent of the rice production in Cambodia was damaged by droughts. [9, P-6]

Table 4 indicates that, in 2010, only 0.12 percent of the total rice fields were damaged by drought. In 2012, the affected and damaged area slightly increased to approximately 0.77 percent. In 2015, the damage increased to 1.62 percent.

<sup>iii</sup> These variations in numbers in each year may be a result of climate change

Table 4: Impacts of Droughts on Arable Rice Land in Cambodia, 2010-2016

Year	Affected Area (Hectare)	Damaged Area (Hectare)	Total Arable Rice Land (Hectare)	Percentage of Affected Area of the Total Rice Land	Percentage of Damaged Area of the Total Rice Land
2010	14,103	2,934	2,391,016	0.59	0.12
2011	3,659	53	2,496,569	0.15	0.00
2012	167,819	19,420	2,512,038	6.68	0.77
2013	9,542	178	2,567,723	0.37	0.01
2014	116,129	20,289	2,564,572	4.53	0.79
2015	252,189	41,469	2,561,957	9.84	1.62
2,016	173,613	16,751	2,599,586	6.68	0.64

Source: Ministry of Agriculture, Forestry and Fisheries, (2010-2016)

Table 5: Impacts of Droughts on Humans (Victims) in Cambodia, 1996-2017

Year	Victims
2001	20,283
2002	842,563
2003	NA
2004	455,327
2005	1,024,335
2006	100,592
2007	NA
2008	31,706
2009	NA
2010	NA
2011	358
2012	25,563
2013	NA
2014	14,631
2015	NA
2016	250,859
2017	NA
<b>Total</b>	<b>2,766,217</b>

Source: National Committee Disaster Management, Cambodia

In addition, Table 5 shows the impact of droughts on human life from 1996 to 2017. In 2002, 2005 and 2016, the numbers of victims were high compared with those of other years.

#### 4. Water Management and Climate Resilience Policies of Cambodia

The National Water Resource Policy (2004)[1, P-14] has several main aims :

- To protect and use water resources in an effective and sustainable way;
- To find solutions to address problems related to the water sector;

- To establish plans and implement strategies and policies for water resource management; and
- To educate water users regarding water use activities including the private and public sectors and to improve people's living standards and to ensure sustainable national economic development.

The policy aims to ensure the development of the country's economy by dealing with issues relating to water resources faced by agriculture, industry, services, tourism and domestic users. The main focus of the policy is the effective use of water resources.[1, P-15] In addition, the policy encourages the development of, and research into, technology, as well as collaboration between line Ministries such as the Ministry of Industry, Mines and Energy (MIME), the Ministry of Rural Development (MRD), the Ministry of Environment (MoE), [6, P-21] and neighboring countries, particularly with members of the Mekong River Commission (MRC). [1, P-15]

#### ***4.1 Water Resources and Climate Change Adaptation Strategies***

In addition to the success in the development of irrigation systems, the improvement of water pumps and pumping stations, sanitation and water supplies, as well as the establishment of Farmer Water User Communities (FWUCs), future plans could include climate change adaptation strategies. [1, P-24] Since the Master Plan of Water Resource Development in Cambodia was developed in 2008, with very detailed and specific management plans for water schemes, by the Ministry of Water Resources and Meteorology (MoWRAM, 2008), adaptation strategies to deal with climate change could concentrate on the following activities: [1, P-24]

- i. Information about the impact of climate change on water resource development and management could be disseminated throughout the country through media and social networks; [1, P-24]
- ii. Human resource skills relating to climate change and water resources could be strengthened through long and short-course training and education exchanges in Cambodia, regionally and overseas; [1, P-25]
- iii. Statistics and data management systems could be developed to accumulate information and share data among relevant actors addressing concerns about water resource issues related to climate change, and the associated adaptation or mitigation capacity; [1, P-25]
- iv. An improved weather forecasting network could be established to predict weather patterns in order to effectively manage the impacts of floods, droughts, temperature variations, and rainfall; [1, P-25]
- v. Financial funds for research could be mobilized, and programs developed for climate change adaptation mitigation strategies relating to water resources from government agencies and development partners; [1, P-25]
- vi. Farmers, especially FWUC members, could be encouraged to plan for less-water crop systems (e.g., crop varieties that need less water) to adapt to climate change. [1, P-25]

#### **- Water management policies for farming related to climate change adaptation**

Agriculture has made a substantial contribution to economic growth and food security in Cambodia. Since this sector has been particularly affected by climate change and water resource issues, the government has taken action to protect water resources and reduce the impact of climate

change.[10, P-105] MoWRAM and MAFF have prioritized some major policies including action to improve human resources and technology, to promote the farming of drought- and flood-resilient crops, to promote and transfer technical support to farmers, to focus on the enhancement of water ecosystems, and to encourage research and development for farming related to climate change adaptation. (Policy established in 2015). [10, P-106]

- **Drought and flood management policy**

The Royal Government has rehabilitated existing, and built new, irrigation infrastructure to respond to water demand from farmers. As a result, the number of water reservoirs has increased and the water supply in rural areas has become more robust. (RGC 2009)[11, P-132] In respect of drought and flood management and prevention, MoWRAM has developed policies to promote flood control and the construction of water drainage aimed at minimizing natural disasters caused by water. This has especially been the case in areas that have high economic potential, and has urgently responded to a need for support in the related communities with the provision of materials and education. The use of water pumps to support rice farming has also been promoted, especially in the areas not covered by irrigation systems (The policy was established in 2009).[11, P-132]

**4.2 Remaining Challenges**

Public expenditure for climate change measures could also be taken into account when discussing the implementation of climate change adaptation plans. One third, or 32.4 percent, of total public expenditure in 2015 was fully or partly distributed with the intention of achieving some degree of climate change benefit. However, this share has remained stable since 2009 at around 30 percent, with an increment in the last two years.[12]

In addition to the slow progress in the level of funding related to climate change, water resource management in Cambodia has also been facing challenges. For example, the Farmer Water User Communities (FWUCs) and the implementation of the master plan for water resource management and development still lack financial support, and the capacity of farmers, and other relevant people and agencies to cope with climate change, remains low.[1, P-35]

While water resource management requires large investments, the current annual financial support is limited. Funds available for the recovery and repair of meteorological forecasting systems, hydraulic infrastructure, and hydrological monitoring systems are also limited. Funding is usually supplied by two major sources: government and supporters. The estimate budget for 2009-2013 was USD 1,250,024,000.00, of which the national budget share was USD 99,500,000.00 and the supporters' contribution was USD 1,150,524,000.00. Currently, funds from supporters are promised (through contracts with donor partners) at USD 206,200,000.[1, P-36] The budget amounts are planned annually, as shown in Table 6.

Table 6: Planned Budget Figures for 2009-2013 (in USD)

Budget year	Supporters and Foreign Investment		National Budget	Total Budget
	Signed agreement	Donor needed		
2009	\$31,200,000	\$0	\$13,902,000	\$45,102,000
2010	\$38,700,000	\$211,785,000	\$23,962,000	\$274,447,000
2011	\$50,300,000	\$224,963,000	\$22,645,000	\$297,908,000
2012	\$46,500,000	\$245,746,000	\$18,000,000	\$310,246,000
2013	\$39,500,000	\$261,830,000	\$20,991,000	\$322,321,000
<b>Total Budget</b>	<b>\$206,200,000</b>	<b>\$944,324,000</b>	<b>\$99,500,000</b>	<b>\$1,250,024,000</b>

Source: Ministry of Water Resources and Meteorology (2012)

## 5. Conclusion

Cambodia has two seasons, rainy and dry, and their nature has been changing in terms of the variations in seasonal rainfall and water flows. Seasonal changes in water distribution as a result of the impact of climate change on water resources has become a main concern in Cambodia. The country needs to engage in the further development of water infrastructure and water management for agriculture to support the sustainability of water resources and to improve its adaptation policy. This study reviewed the status of water resources in Cambodia by focusing on the current impact of climate change and the challenges posed by floods and droughts, and policies for water management for climate resilience in Cambodia.

Climate change can cause an increase in rainfall in the rainy season (inducing flash floods) and a longer dry season (inducing drought). These natural disasters happen through the degradation of water resources as a result of the change in the flow of the Mekong River, which seriously impacts water distribution to agriculture and therefore has an effect on people's livelihoods. For instance, the flood event in 2011 damaged almost 11 percent of the total arable rice land, which is the largest amount of damage compared with that caused by floods in other years from 2010 to 2016. In respect of rural livelihoods, death, injury and damaged houses, the effects were the most severe in the 2000 and 2011 flood events. Also, droughts left more than one million victims in 2005 and damaged almost 2 percent of arable rice land in 2015.

Based on the research conducted for this paper, it appears that Cambodia still faces problems regarding water resources, droughts, floods, and lack of water for agriculture. The implementation of existing policies has not been totally effective and further attention could be given to both the water resilience policies and water resource and climate change adaptation strategies.

For example, the provision of information relating to the impact of climate change on water development and water resource management through media and social networks could be

improved, enhancing the human capacity to cope with climate change and threats to water resources through long and short-course training and education tours and exchanges in Cambodia, in the region and overseas. Also, the weather forecasting network could be improved and the information widely disseminated. Finally, action could be taken to increase funds earmarked for research and program development to address climate change adaptation, including the farming of drought-resistant, sustainable crops.

The government has produced an effective master plan and policies for implementation. However, challenges in addressing all issues with regard to climate change and water resources, agriculture, natural disasters and livelihoods remain. Both financial and technical support for water resource conservation and climate change adaptation could receive more attention. The effective implementation of the policies, strategies and master plan, with the close collaboration of related Ministries, committees, and international agencies, is also important.

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