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A Comprehensive Report

Readiness Assessment for Impact-based Forecasting and Warning (IbFW) in Cambodia

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Readiness Assessment for Impact-based Forecasting and Warning (IbFW) in Cambodia

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ABBREVIATIONS

ADB	Asian Development Bank
ADPC	Asian Disaster Preparedness Center
AFD	Agence Française de Development
CCDM	Commune Committee for Disaster Management
CMIP5	Coupled Model Intercomparison Project Phase 5
CRC	Cambodian Red Cross
CREWS	Climate Risk and Early Warning Systems
DDA	District Department of Agriculture
DCDM	District Committee for Disaster Management
DHRW	Department of Hydrology and River Works
DIMS	Disaster Information Management System
DOM	Department of Meteorology
FAO	Food and Agriculture Organization
FGD	Focus Group Discussions
FWUC	Farmer Water User Committees
GDP	Gross Domestic Product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GFDRR	Global Facility for Disaster Reduction and Recovery
IBFW	Impact-Based Forecasting and Warning
JICA	Japan International Cooperation Agency
KII	Key Informant Interviews
KOICA	Korea International Cooperation Agency
LDCF	Least Developed Countries Fund
MAFF	Ministry of Agriculture, Forestry and Fisheries
MoWRAM	Ministry of Water Resources and Meteorology
NCDM	National Committee for Disaster Management
NMHS	National Meteorological and Hydrological Services
PCDM	Provincial Committee for Disaster Management
PDAFF	Provincial Department of Agriculture, Forestry, and Fisheries

PDoWRAM	Provincial Department of Water Resources and Meteorology
PRISM	Platform for Real-time Impact and Situation Monitoring
RCP	Representative Concentration Pathways
SDC	Swiss Agency for Development and Cooperation
TMD	Thailand Meteorological Department
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
WFP	World Food Programme
WMO	World Meteorological Organization

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EXECUTIVE SUMMARY

Impact-based forecasting and warning is a structured approach for combining hazard, exposure, and vulnerability data to identify risk and support decision-making, with the aim to reduce damages and loss of life from natural hazards through early action. While traditional forecast providing scientifically accurate information is important, it is also equally important to communicate to the people on how to respond effectively to hazard risks. In order to do so, it will require very specific information and relevant potential consequences with respect to local contexts, not just for public end-users, but also for different sectors and agencies.

Impact-based forecasting and warning (IbFW) goes beyond forecasting hydro-meteorological events such as floods or droughts into estimating the extent, location, and severity of the impact from those of hydro-meteorological events. To implement successful IbFW, Hydro-met agencies need to strengthen their capacity to adequately monitor hydro-meteorological parameters, improving their existing communication system for data transmission and dissemination of forecasts information including high speed computing system for data assimilation and ensemble forecasting. Similarly, NDMOs will need to be able to receive such forecast information, understand it and be able to use it for emergency preparedness and early response actions. For this to be achieved, institutional capacity building is needed to enhance the capacity of individual institutions so that knowledge and skills on IbFW is built and operational planning and decision-making is improved.

ADPC in partnership with WFP has conducted a readiness assessment of Impact-based Forecasting and Warning (IbFW) in Cambodia to improve the institutional capacities of national stakeholders such as the National Meteorological and Hydrological Services (NMHS), the National Disaster Management Offices (NDMOs) and the Ministry of Agriculture so that the existing mechanism for impact-based forecasting information are improved for operational planning and decision-making. The readiness assessment (RA) was carried out to provide a better understanding of the current capacity and gaps on IbFW implementation of these institutions and how the expertise of Asian Disaster Preparedness Center (ADPC) and the World Food Programme (WFP) can be leveraged to further strengthen and enhance such capacities at individual and organizational levels. The overall IbFW readiness assessment in Cambodia was carried out based on the six key areas that includes (i) Level of Understanding about IbFW; (ii) Stakeholder Mapping and Assessment of IbFW Understanding Level (iii) Risk and Impact Assessment (iv) IbFW Generation; (v) IbFW Dissemination; and (vi) Forecast/Impact Verification as defined under international and regional guidelines of IbFW. Overall assessment results from Cambodia have suggested limited capacity on IbFW ranging from low (Score of 2) to medium (Score of 3). The overall recommendation suggests more training and capacity building at institutional level enhancing the capacity on the use of IbFW in Cambodia.

Section A: Introduction

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Hydro-meteorological hazard risk, fueled by extreme weather events reached beyond coping capacities of many countries in Asia and the Pacific and extreme weather events in recent past have shown the devastating impacts on people and property (Thomas et al., 2014; UNESCAP, 2019). Countries in Southeast Asia are severely affected by recurrent hydro-meteorological hazards such as droughts, floods, cyclones and storm surge and owing to climate change, frequency and intensity of such hydro-meteorological hazards is on rise and impacts are manifold (Pulwatry and Sivakumar, 2014; UNESCAP, 2019). Hydro-meteorological hazards in the Southeast Asian countries pose direct and indirect impacts on lives and livelihoods by damaging and destroying key lifeline infrastructure, businesses, and agriculture (Pulawatry and Sivakumar, 2014). Impact based forecasting and warning is one of the cost-effective non-structural mitigation measures to monitor and manage hydro-meteorological hazards all over the globe (WMO, 2015; UK Met, 2020; UNESCAP, 2021). Impact based foresting and warning system provide an opportunity to emergency services as well as communities to act with knowing the impact of impending hazard with adequate lead time before onset of any hydro-meteorological hazard to reduce risk to life by evacuation from risk prone areas, and also to protect possessions and properties (Sai et al., 2018; Merz et al., 2020; Dashora, 2020; L M Sidek et al., 2021). Impact-based forecasting and warning (IbFW) play significant role in all phases of disaster management cycle including, Preparedness, Response, Recovery and Mitigation, which requires collective and coordinated efforts by various stakeholders at different level from national to community (Sai et al., 2018; Merz et al., 2020; Dashora, 2020; L M Sidek et al., 2021). Effectiveness and reliability of an Impact-based forecasting and warning system depend on many factors such as hazard, exposure and vulnerability information, risk information, architecture of forecast system, technology used during development of forecast products and most important capacities of Impact-based forecasting and warning information producers, co-producers and users such as national meteorological and hydrological services and national disaster management organizations (Sai et al., 2018; Merz et al., 2020; Dashora, 2020; L M Sidek et al., 2021; Wei et al., 2018). Impact-based forecasting and warning essentially comprises of three major key components including Co-design IBFW, Co-production IBFW and Delivery IBFW (UK Met, 2020). There are six sub-components linked to these three-key components of impact-based forecasting and warning. Many stakeholders from national to local levels need to coordinate well across these three components for an effective Impact based forecasting and warning to work. Failure in one component or lack of coordination across them could lead to the failure of the whole system (Sai et al., 2018, Merz et al., 2020, Dashora, 2020; L M Sidek et al., 2021, Bierens et al., 2018).

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In addition to these key component, governance and gender are also important cross-cutting components to support each component and sub-component for have an effective and people-centric impact-based forecasting and warning system. Impact-based forecasting and warning supported by effective institutional capacities and advanced technologies can predict hazards' impacts in a timely and effective manner, thereby assessment and accordingly enhancement of capacities of national meteorological and hydrological services are significant steps towards achieving overall targets of Sendai Framework for Disaster Risk Reduction. As mentioned previously, responsibilities of issuance of impact-based forecasting and warning are a mandate of national meteorological and hydrological services; thus, readiness capacities of such institutions for better implementation of impact-based forecasting and warning should be well assessed time to time and reflected in the regional to national regulatory frameworks, planning, budgetary, coordination, and operational mechanisms. Traditionally, majority of research was focused only on early warning system technologies and infrastructure and limited attention was given to readiness capacities of producers, co-producers, and users on impact-based forecasting and warning.

However, in recent past the focus also shifted towards understanding capacities and needs of national meteorological and hydrological services (Bhat et al., 2013; Dutta et al., 2015; Dutta et al. 2018; Haigh et al., 2018; Sufri et al., 2020; Hippola et al., 2020, Dashora, 2020). Impact-based forecasting goes beyond forecasting hydro-meteorological events such as floods or droughts into estimating the extent, location, and severity of the impact from those hydro-meteorological events. The impact-based forecasting will make emergency preparedness and early response more effective since the efforts, usually by NDMOs, will be targeted to the potential impacted areas. To implement successful impact-based forecasting, countries need to enhance their capacity. Hydro-met agencies need to strengthen their capacity to adequately monitor hydro-meteorological parameters, improving their existing communication system for data transmission and dissemination of forecast information including high speed computing system for data assimilation and ensemble forecasting. NDMOs will need to be able to receive such forecast information, understand it, and be able to use it for emergency preparedness and early response actions. Institutional capacity building is needed. Capacity development is the process through which individuals, organizations and societies obtain, strengthen and maintain the capabilities to set and achieve their own development objectives over time. Capacity development is not a one-off intervention but an iterative process of design-application-learning-adjustment. Therefore, it is important to assess the existing capacities and gaps and what additional capacities would be required to support the capacity development process of a country. The RA will help in evaluating the actual existing gaps within targeted organizations in terms of knowledge, skills, strengths and gaps required for them to achieve the pre-specified objectives. In the present assessment an attempt was made to assess and visualize readiness of

impact-based forecasting and warning producers, co-producers and users at national level in two countries of Lower Mekong Region including Cambodia and Lao PDR.

A.2 | Cambodia

Cambodia is located in Southeast Asia, surrounded by Lao PDR in the North, Thailand in the West, and Vietnam in the East, and having a 440 km long coastline section on the Gulf of Thailand in the South. Cambodia is well known for its plains. Cambodia has a population of roughly 15.6 million people, according to General Population Census of Cambodia of 2019[1]. Despite the fact that 76 percent of Cambodia's population now lives in rural regions, the country is undergoing a high rate of urbanization. Cambodia is an agriculture-based economy and its population is largely reliant on agriculture and fishing, which generate 25 percent of the country's GDP and employ 49 percent of the country's work force, respectively (ADB, 2021[2]). The industries and services sectors are expanding at a rapid pace in Cambodia and its contribution to economy will increase in near future. Mekong river is one of the key geographical features of Cambodia, which highly influence the life and livelihood of the country. Mekong river flows from Lao PDR in the North to the Mekong River Delta in Vietnam in the South. **Figure (1)** represents the map of Cambodia.

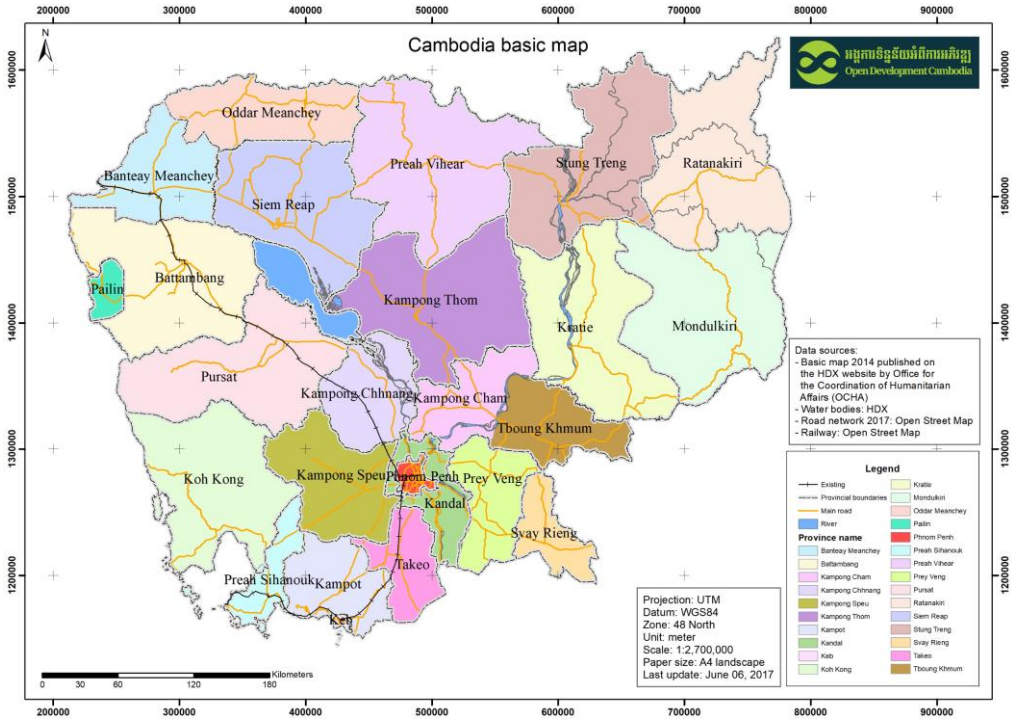

Figure (1): Map of Cambodia **(**Source: Open Development Cambodia[3])

[1] General Population Census of Cambodia 2019. URL: https://www.nis.gov.kh/nis/Census2019/Final%20General%20Population%20Census%202019-English.pdf

[2] Asian Development Bank (2021). Climate Risk Country Profile of Cambodia. URL: https://www.adb.org/sites/default/files/publication/722236/climate-risk-country-profile-cambodia.pdf

[3] UN (n.d.). URL: https://data.opendevelopmentcambodia.net/dataset/administrative-boundaries-of-cambodia-2014

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Tonle Sap Lake is another key geographical feature of Cambodia, which is an essential natural resource, covers almost 10% of the country's surface area at its maximum capacity during the Southwest Monsoon season. It also serves as the country's major protein supply and is a critical natural resource for the country. The Tonle Sap Basin is a vast alluvial plain surrounded by hills that is home to a variety of wildlife. The mainline splits into a complicated network of channels that branch out and reunite near the southern end of the basin. Tonle Sap Lake is the largest freshwater body in Southeast Asia. It is located in the Cambodian floodplains and also known as the Great Lake. The lake is comprised of the western and central sections of the Tonle Sap Basin. During the dry season, the Tonle Sap River feed into the Mekong River, which is connected to the Tonle Sap Lake. High flows in the Mekong River during the rainy season lead the Tonle Sap River to change its flow direction, causing the Great Lake to be flooded. Its surface area grows six-fold during peak flood season, from about 2,500 km^2 to approximately 15,000 km^2, and its volume swells six-fold, from approximately 1.5 km^3 to around 60-70 km^3, at peak flood season. At the end of the Monsoon season, the Tonle Sap River's flow reverses to the downstream direction, emptying surplus water from the flooded floodplain surrounding the Great Lake and into the ocean. This hydrological cycle helps to maintain the lake's diverse biodiversity, which includes a diverse range of fish, animals, and plants on which many local populations rely for their subsistence. Cambodia's Great Lake and floodplains provide both a means of subsistence and a source of food for over half of the country's population. **Figure (2)** represents map of Tonle Sap Lake with areas under permanent water and seasonal flooding.

Figure (2): Tonle Sap Lake (Source: Thirdpole, n.d.[4])

[4] Third Pole (n.d.). URL: https://www.thethirdpole.net/en/livelihoods/cambodian-farmers-can-no-longer-rely-on-tonle-sap-lake/

Section A: Introduction

1. Climate Trends

1.1 Baseline Assessment

Cambodia has a tropical climate with the three distinct seasons: first is rainy season between May–October driven by monsoons and south-westerly winds bringing clouds and moisture that account for 80–90 percent of annual precipitation, second is dry season (cold) between November–January with cooler temperatures, and third is dry season (hot) particularly between February to April (World Bank, n.d[5]).

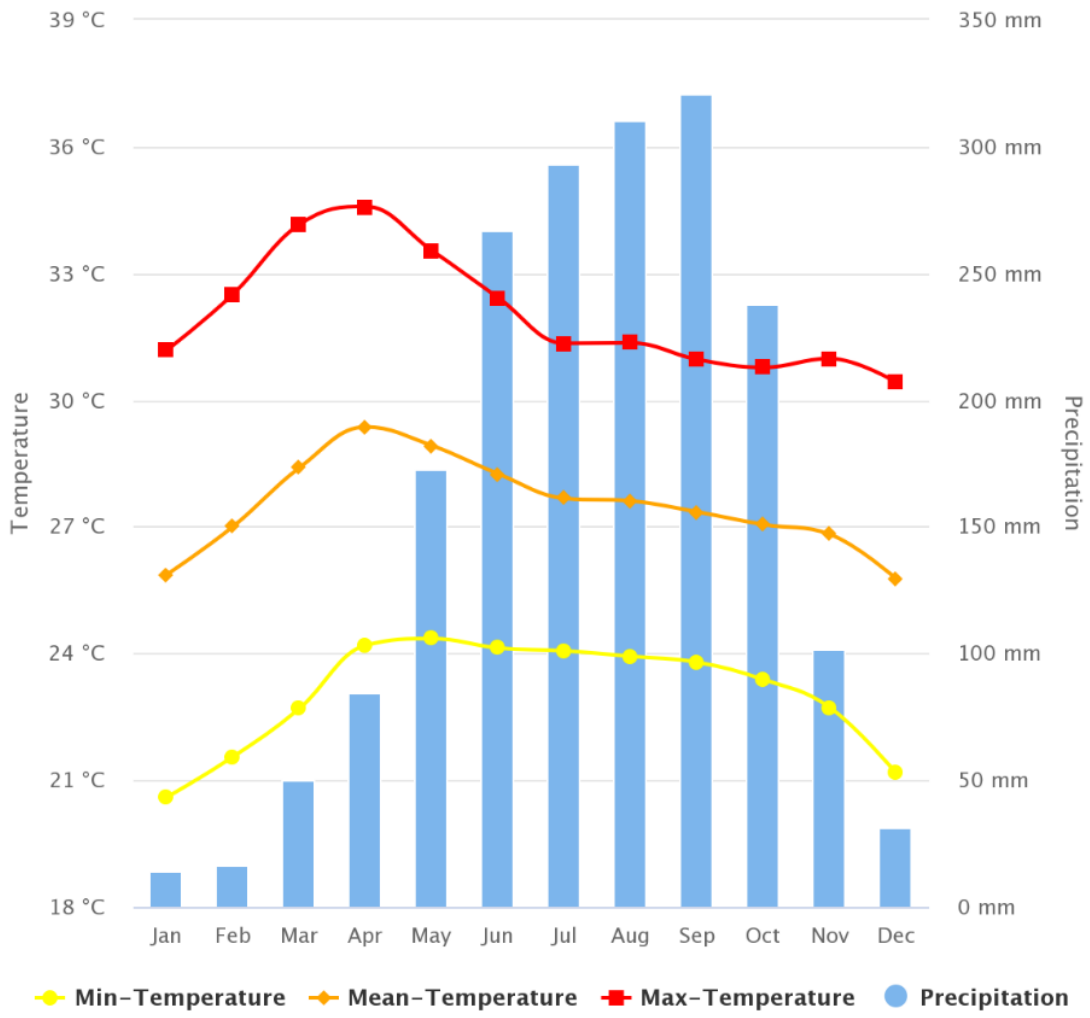

Figure (3): Average monthly temperature and precipitation in Cambodia (1991–2020) (Source: World Bank, n.d.[6])

[5] World Bank (n.d.). Climatology of Cambodia. URL: https://climateknowledgeportal.worldbank.org/country/cambodia/climate-data-historical

[6] World Bank (n.d.). Climatology of Cambodia. URL: https://climateknowledgeportal.worldbank.org/country/cambodia/climate-data-historical

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The country's average temperatures are very consistent, however early summer temperatures regularly surpass 32°C, just before the rainy season begins. In the remaining months of the year, temperatures ranging between 25–27°C. The summer monsoon, from May to November, brings heavy rainfall to the southeast and northwest. The annual rainfall is about 3000 mm, with greater rates in coastal and highland areas and lower rates elsewhere (World Bank, n.d[7]). The El Niño–Southern Oscillation (ENSO) affects the character of the monsoons in the region. El Niño provide warmer and drier winters to Southeast Asia, whereas La Niña brings colder winters. **Figure (3)** represents month wise average temperature and precipitation in Cambodia (1991–2020).

Cambodia's climate is mainly dominated by monsoons, which are known as tropical wet and dry because of the distinctly marked seasonal differences. The monsoonal airflows are caused by annual alternating high pressure and low pressure over the Central Asian landmass. The southwest monsoon brings the rainy season from May to October.

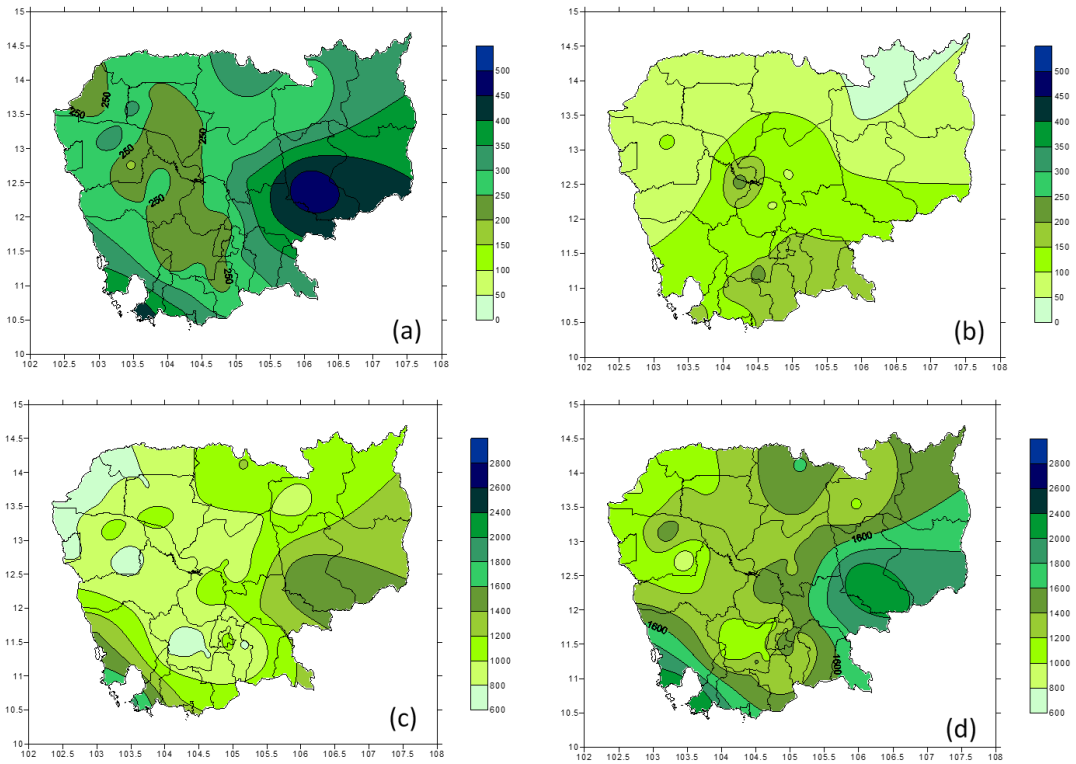

Figure (4): Distribution of Average total Rainfall (in mm) in Cambodia during (a) Dry Season (hot); (b) Dry season (Cold); (c) Rainy Season and (d) Annual (Mar-Feb)

[7] World Bank (n.d.). Climatology of Cambodia. URL: https://climateknowledgeportal.worldbank.org/country/cambodia/climate-data-historical

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The coastal regions as well as southeast regions receive the highest rainfall amounts annually, about 3,000 mm/year, while the highlands and lowlands receive 2,000 mm/year and 1,200 mm/year, respectively. The northeast monsoon flow of drier and cooler air lasts from early November to April. This results in two dry seasons, hot and cold, from February through April and November through January, respectively. On average, the annual rainfall in Cambodia is a bit higher than that of other countries in the region. **Figure (4)** represents the distribution of rainfall in seasons.

During the rainy season, from May to October, minimum average temperatures drop to about 22 °C, and during the dry season from November to April, maximum average temperatures rise to about 40 °C. Southwest monsoons bring moisture winds from the Gulf of Thailand and the Indian Ocean from May to October. The northeast monsoon is the dry season, from November to April. The country experiences the heaviest precipitation from September to October and the driest period from February to April.

The average annual temperature in Cambodia is between 25°C and 27°C. In April, the average maximum temperature is 38°C and the average low is 17°C. Temperatures have risen by 0.18°C each decade since the 1960s. Temperatures have risen by 0.20°C to 0.23°C each decade during the dry season (November-April). During the rainy season (May-October), temperatures have risen slightly, by 0.13°C to 0.16°C each decade. The number of 'hot days' in the country has grown by 46 days each year in the previous century (World Bank, n.d[8]; ADB, 2021[9]). Cambodia's rainfall greatly varies in different parts of country. The yearly rainfall ranges from 1,400 mm in the central plains to over 3,000 mm or more between the Cardamom highlands and the southwest coast. The eastern plains of Cambodia receive 2,000 to 2,600 mm of rain annually, with some hilly tracts in the Northeast receives more. While certain places have had increased rainfall during the 1960s, there were no statistically significant changes in yearly rainfall or severe occurrences over the last century. However, precipitation variability is connected to the El Niño Southern Oscillation, with strong El Niño years correlating with moderate to severe drought (World Bank, n.d[10]; ADB, 2021[11]).

[8] World Bank (n.d.). Climatology of Cambodia. URL: https://climateknowledgeportal.worldbank.org/country/cambodia/climate-data-historical
[9] Asian Development Bank (2021). Climate Risk Country Profile of Cambodia. URL: https://www.adb.org/sites/default/files/publication/722236/climate-risk-country-profile-cambodia.pdf
[10] World Bank (n.d.). Climatology of Cambodia. URL: https://climateknowledgeportal.worldbank.org/country/cambodia/climate-data-historical
[11] Asian Development Bank (2021). Climate Risk Country Profile of Cambodia. URL: https://www.adb.org/sites/default/files/publication/722236/climate-risk-country-profile-cambodia.pdf

1.2 Climate Projection

The Coupled Model Inter-comparison Project Phase 5 (CMIP5) models are the major global data source for the predictions of future climate including temperature and precipitation. The Representative Concentration Pathways (RCPs) describe four different 21st century pathways of greenhouse gas (GHG) emissions and atmospheric concentrations, air pollutant emissions and land use. The RCPs have been developed using Integrated Assessment Models (IAMs) as input to a wide range of climate model simulations to project their consequences for the climate system. These climate projections, in turn, are used for impacts and adaptation assessment.

Each of the four Representative Concentration Pathways (RCP) are characterized by its total radiative forcing pathway and level by 2100 (RCP2.6, RCP4.5, RCP6.0, and RCP8.5). The research focuses on RCP2.6 and RCP8.5, the low and high emissions trajectories. RCP2.6 implies substantial mitigation, whereas RCP8.5 assumes business as usual (IIASA, n.d.). These models show a steady warming trend for Cambodia, varying by GHG scenario. But rainfall forecasts are less clear. Forecasts predict a rise in the frequency and severity of heavy rain episodes, along with an increase in total rainfall (ADB, 2021[12]).

Figure (5) represents historic and projected average annual temperature in Cambodia under RCP2.6 (blue) and RCP8.5 (red).

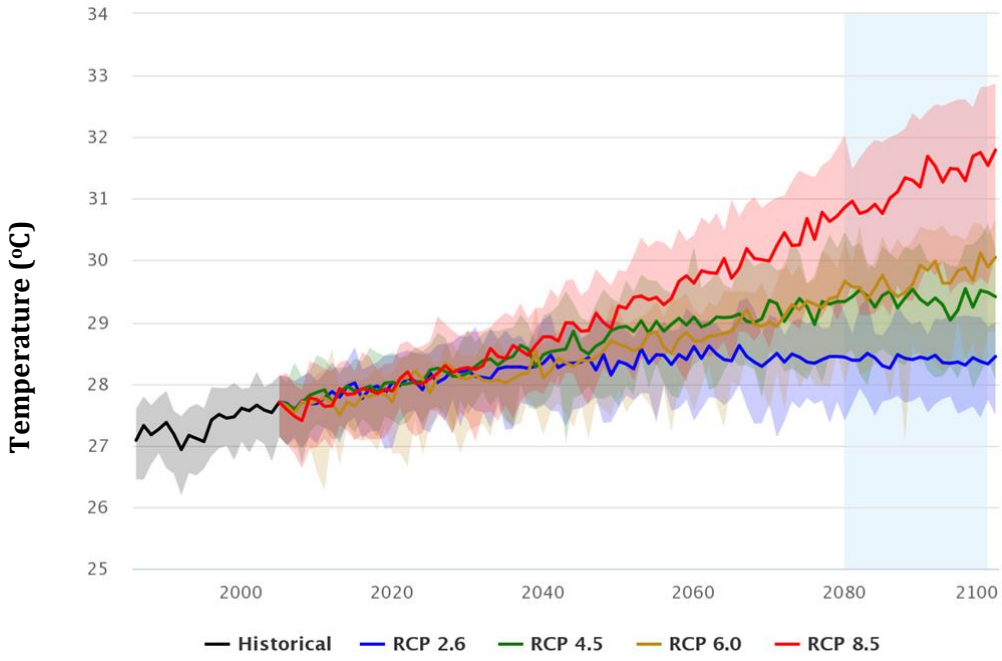

Figure (5): Historic and projected average annual temperature in Cambodia under RCP2.6 (blue) and RCP8.5 (red) (Source: World Bank, n.d.[13])

[12] Asian Development Bank (2021). Climate Risk Country Profile of Cambodia. URL: https://www.adb.org/sites/default/files/publication/722236/climate-risk-country-profile-cambodia.pdf

[13] World Bank (n.d.). Future Climate Change. URL: https://climateknowledgeportal.worldbank.org/country/cambodia/climate-data-projections

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Box (1): Climate Summary of Cambodia

- *Under the highest emissions scenario, RCP 8.5, warming in Cambodia is expected to rise by 3.6°C by the 2090s compared to the baseline circumstances from 1986 to 2005.*
- *Without intervention, the vulnerable population to catastrophic fluvial flooding might increase by about 4 million by the 2040s; however, human development factors may influence future flood dynamics.*
- *Climate change and human influences on the Mekong River's hydrological regime, threaten the life and livelihood and to reduce the productivity of Tonle Sap Lake and Cambodia's fisheries – a significant threat to the livelihoods and nourishment of many poor, rural communities.*
- *Climate change projections suggest more severe floods and droughts, which are anticipated to reduce Cambodia's GDP by about 10% by 2050.*
- *Due to projected increases in the incidence of extreme events during the growing season, there is a need for various adaptation interventions to reduce crop production, particularly for vulnerable communities operating at small level and reliant on rain-fed agriculture.*

2. Riskscape of Cambodia

Cambodia is vulnerable to a wide range of hydro-meteorological hazards, including floods, droughts, severe storms, typhoons, and lightning strikes, among others. **Table (1)** represents Riskscape of Cambodia.

Table (1): Summary of Riskscape of Cambodia

Capital: Phnom Penh
Location: 12.5657° N 104.9910° E
Geographical Area: 181,035 km²
Number of Provinces: 25
Number of Districts: 163
Population: 15,552,211[14]
Male: 7,571,837 | Female: 7,980,374
WMO Region: II | Asia
NMS: Department of Meteorology (DOM), Ministry of Water Resources and Meteorology (MoWRAM), Government of Cambodia

Figure (6.1): Geographical Location

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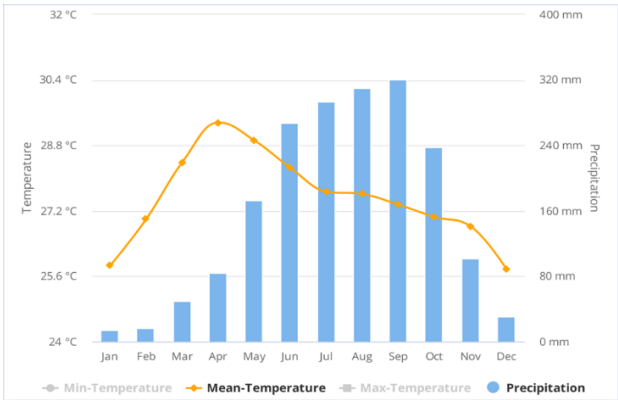
WMO Member: December 1955[16] **NHS**: Department of Hydrology and River Works (DHRW), MoWRAM, Government of Cambodia	Source: National Institute of Statistics[14] **Figure (6.2):** Monthly Climatology of Mean-Temperature and Precipitation in Cambodia from 1991-2000
Germanwatch Global Climate Risk Index: Climate Risk Index Score: 75.83[17] Climate Risk Index Rank: 84	
INFORM Country Profiles: INFORM Risk Index: 4.6[18] INFORM Risk Rank: (57) INFORM Risk Class: Medium INFORM Hazard and Exposure Index: 3.9 INFORM Vulnerability Index: 4.0 INFORM Lack of Coping Capacity: 6.1	Source: The World Bank[15]

Flood and drought are the two major natural hazards in Cambodia, which are exacerbated by the country's high levels of exposure and susceptibility. Floods and drought are also recognized as potential natural hazards along with climate change in the National Action Plan for Disaster Risk Reduction (NAP-DRR, 2014-2018[19]). Several locational factors such as distinct geography, demographic trends, socio-economic factors, and limited adaptive capacities have an important role in determining level of vulnerability; for example, the floodplains along the Mekong are more vulnerable to river floods, whereas mountain ranges (such as the Cardamom) are more susceptible to isolated landslides and flash flooding (GFDRR, n.d.). **Figure (7)** represents Global Climate Risk Index Ranking from 2000-2019.

According to the 2022 INFORM Risk Index, Cambodia has a high degree of catastrophe risk, ranking 57th out of 191 nations (EU, 2021). This is mostly due to the country's high exposure and vulnerability to flooding (GFDRR, n.d.). Cambodia is highly vulnerable to flooding (it is ranked equal 3rd in the world), which includes riverine and flash floods (EU, 2021). Cambodia also has exposure to tropical cyclones and their associated hazards, and while the country's drought exposure is slightly lower than the global average, it is still a significant source of

[16] WMO (n.d.), https://public.wmo.int/en/about-us/members
[14] National Institute of Statistics (n.d.). URL: https://www.nis.gov.kh/nis/Census2019/Final%20Geneal%20Population%20Census%202019-English.pdf
[15] The World Bank (n.d.). URL: https://climateknowledgeportal.worldbank.org/country/cambodia/climate-data-historical
[17] Germanwatch (2021). URL: https://germanwatch.org/sites/default/files/Global%20Climate%20Risk%20Index%202021_2.pdf
[18] European Union (2021). Inform Risk Index-2022 https://drmkc.jrc.ec.europa.eu/inform-index/INFORM-Risk/Results-and-data/moduleId/1782/id/433/controller/Admin/action/Results
[19] NAP-DRR (2014-2018). URL: https://www.rcrc-resilience-southeastasia.org/wp-content/uploads/2017/12/2014_national_action_plan_for_disaster_risk_reduction__nap-drr__2014-2018_english.pdf

concern, as demonstrated by the severe drought that occurred in the country from 2015 to 2017. Cambodia's overall rating on the INFORM risk index is 4.6 (Medium to High), which compounded to some extent by a lack of coping capacity and higher susceptibility of the people. Many studies highlighted that Cambodia along with Bangladesh, and Vietnam are the countries with the largest proportional share of people and the highest percentage of GDP that is vulnerable to floods (Kundzewicz, et al., 2014; World Bank, 2015; Willner, et al., 2018; ADPC, 2019; ADB, 2021).

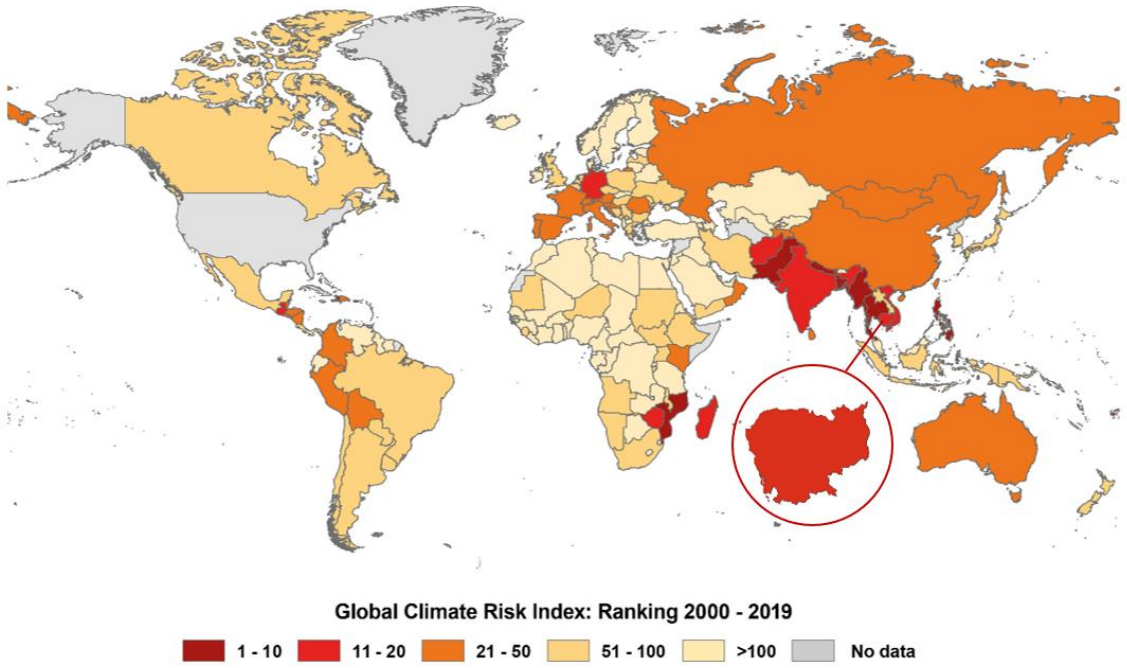


Figure (7): Global Climate Risk Index: Ranking 2000-2019 (Source: Germanwatch, 2021[20])

2.1 Floods

Cambodia faces two major types of floods; including fluvial floods (sometimes referred as Riverine floods or Mekong floods) and flash floods.

Fluvial Floods

As a result of cumulative rainfall in the upper catchments during the rainy season, water levels in the entire catchments rise slowly but steadily over a period of many days. There are two main reasons that might flood conditions make more critical. First and foremost, when floods occur in conjunction with severe rains around the Tonle Sap Lake, which affects the provinces surrounding the lake as well as the southern provinces, the situation becomes dire. Second, the most catastrophic floods occur when heavy rains coincide with the arrival of tropical depressions and storms, which causes flash flooding to occur. Fluvial flooding of the Mekong River occurs often in the provinces of Stung Treng, Kratie, Kampong Cham, Tboung Khmoum,

[20] Germanwatch (2021). Global Climate Risk Index: Ranking 2000-2019. URL: https://germanwatch.org/sites/germanwatch.org/files/2021-01/cri-2021_map_ranking_2000_-_2019.jpg

Prey Veng, Svay Rieng, Kandal, and Takeo, among others (GFDRR, n.d.). In addition to Mekong River, overflow of water from Tonle Sap Lake, Tonle Sap river and other main streams round the lake cause flood in some other provinces such as Banteay Meanchey, Battambang, Pursat, Kampong Chhnang, Kampong Thom and Siem Reap (MRC, 2018[21]).

Flash Flood

Heavy rainfall in hilly regions, which drains into streams and tributaries of the Mekong River, frequently results in flash floods in the area. Since September 2021, Cambodia has experienced heavy rainfall across much of the country. As of 22 October 2021, about 28,468 households in 5 provinces are reported to be affected by flash floods and river floods. In these areas, houses, infrastructure (roads, schools, health centres) and agricultural land have been inundated (HRF, 2021[22]). Despite the fact that these floods are fast and only last a few hours or a day, they frequently cause serious damage to agriculture and infrastructure. Historical flash flood events in Cambodia have been recorded in the provinces of Kandal, Kampong Speu, Kampot, Pursat, Battambang, Kampong Chhnang, Rattanakiri, Preah Vihea, and Odor Meanchey (GFDRR, n.d.).

Figure (8) represents flood affected provinces (from 1996 to 2020) in Cambodia showing the number of recorded events.

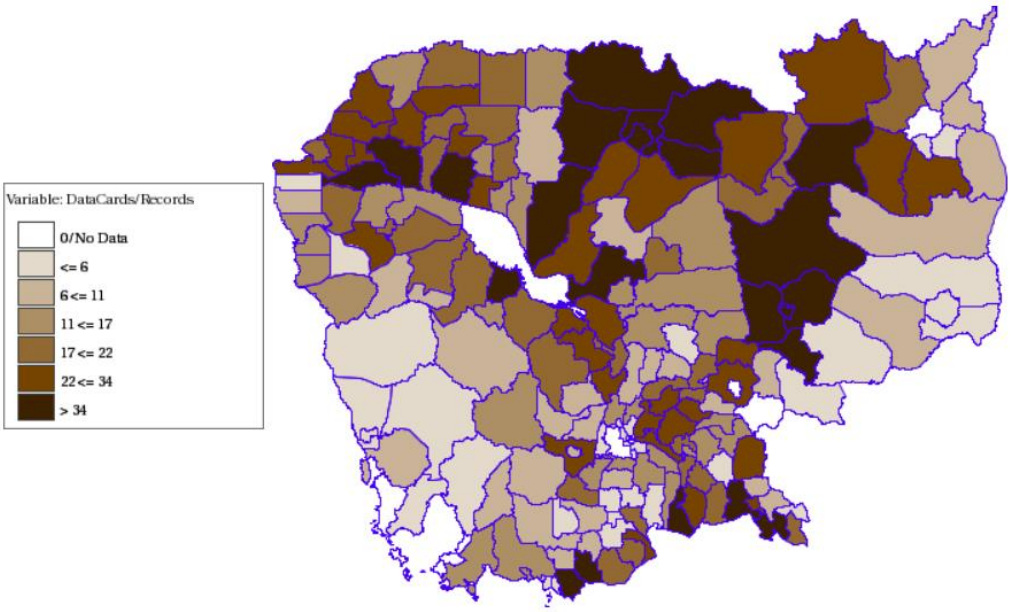


Figure (8): Flood affected provinces (from 1996 to 2020) in Cambodia showing the number of recorded events (Source: NCDM Disaster Database (http://camdi.ncdm.gov.kh/)[23])

[21] https://www.mrcmekong.org/assets/Publications/Council-Study/Council-study-Reports-Thematic/Flood-Sector-Key-Findings-Report-Jan-2018.pdf

[22] Humanitarian Response Forum (HRF) , 2021. URL: https://www.humanitarianresponse.info/sites/www.humanitarianresponse.info/files/documents/files/hrf_sitrep_flood_2021_no2_22-oct-2021.pdf

[23] NCDM (n.d.). Flood Disaster Database. URL: http://camdi.ncdm.gov.kh/

2.2 Drought

As mentioned in previous sections, droughts are also among the most common hydro-meteorological hazards in Cambodia. Climate change is causing more frequent droughts, affecting agriculture production, food security, and natural resources. The southwest monsoon, which spread over five to six months from mid-May to mid-October, brings most of rainfall in Cambodia. The monthly rainfall distribution results in a wet season from May to October and two dry seasons from February to April and November to January . Cambodia has somewhat higher yearly rainfall than other neighbouring nations in the Southeast Asia.

Despite the country's excellent rainfall distribution, droughts have occurred many times in the country. Cambodia's worst drought years were 2002 and 2004. The 2002 drought hit 420 communes, 76 districts in 10 provinces (NCDM, 2009). There provinces were Prey Veng, Kandal, Kampong Speu, Takeo, Svay Rieng, Kampong, Thom, Kampong Cham, Kratie, Odor Meancheay and Banteay Meanchey (NCDM, 2009).

According to UNDP (2021), it appears that Cambodia suffered maximum reported drought events between 2000 to 2009, when comparing to the 2010 to 2019. However, while the former suffered more late-season drought (October-November), the latter experienced more early-season drought (February-March) (June-July). Mid-season drought did not differ much between the two time periods. There have been many instances of droughts, which have resulted in significant losses, mostly in the agricultural production. Recent drought events, such as those that occurred in 2015 and 2016, affected not just agricultural sectors but also domestic water availability. Cambodia was mostly focused on the agricultural regions while reporting on drought impacts in the past. These agriculture regions were mostly affected and destroyed by the drought, such as in 2004, which was one of the worst years for drought impacts in the country's history. **Figure (9)** represents drought affected provinces from 1996 to 2020 in Cambodia.

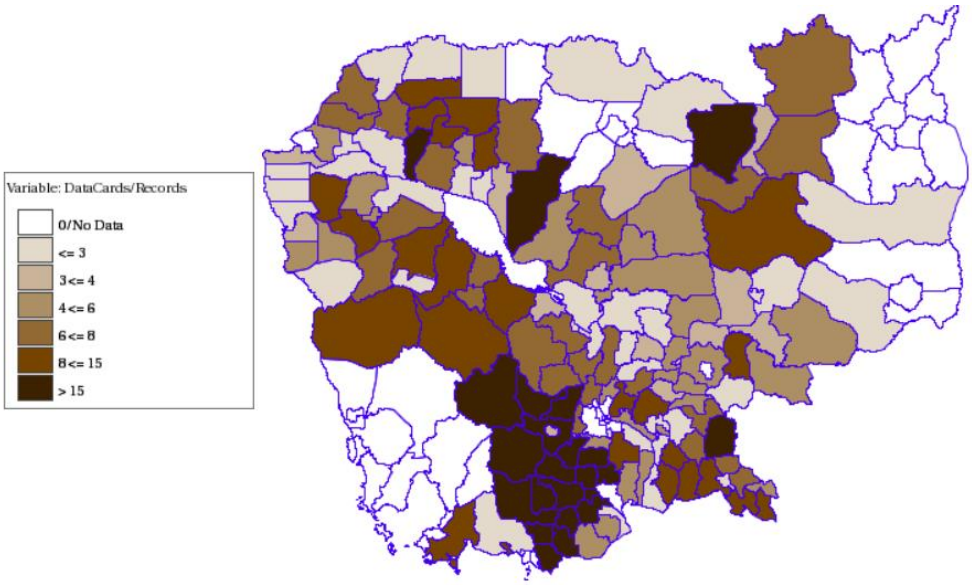


Figure (9): Drought affected provinces (from 1996 to 2020) in Cambodia showing the number of recorded events (Source: NCDM Disaster Database (http://camdi.ncdm.gov.kh/)[25])

2.3 Tropical Storm

Northeastern, Eastern and Southeastern parts of Cambodia are highly vulnerable to typhoons and associated strong winds and precipitation. Approximately 30 tropical storms hit Cambodia between 1999 and 2013. It is worth to add here is that typhoons are now becoming even more severe, and recent events of Noul 2008 and Ketsana 2009 were such examples. Tropical storms can have a maximum impact on the amount of flooding that occurs along the Mekong River and its tributaries in particular months of a year. Tropical storms also can cause large-scale damage to Eastern and Southeastern parts of Cambodia, namely provinces such as Ratanak Kiri, Mondul Kiri, Kratie, Kampong Cham, Svay Rieng, Prey Veng, Kandal and Takeo as they are more vulnerable to typhoons and associated hazards. Tropical storm enters from the South China Sea into the Mekong basin extended east and southeast, across Vietnam and the southern Chinese province of Guangxi. During the months of September and October, maximum amount of damage occurs, since the seasonal discharge of the Mekong River is already high and a second substantial peak to the yearly flood is created (NCDM, 2009).

According to the ADB (2021)[26], Cambodia's coastal zones are known to be vulnerable to tropical storm and tsunami-induced surge, but at a lesser level than that of a number of other Southeast Asian countries. **Figure (10)** represents tropical storm affected provinces from 1996 to 2020 in Cambodia.

[24] NCDM (n.d.). Flood Disaster Database. URL: http://camdi.ncdm.gov.kh/
[25] NCDM (n.d.). Flood Disaster Database. URL: http://camdi.ncdm.gov.kh/
[26] [26] Asian Development Bank (2021). Climate Risk Country Profile of Cambodia. URL: https://www.adb.org/sites/default/files/publication/722236/climate-risk-country-profile-cambodia.pdf

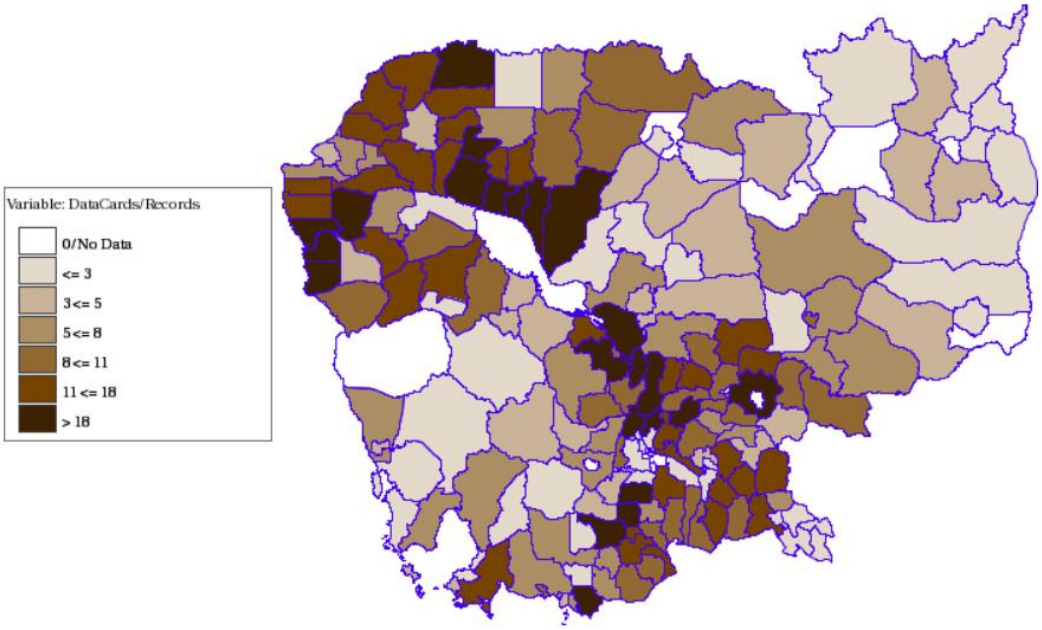


Figure (10): Storm affected provinces (from 1996 to 2020) in Cambodia showing the recorded storm events (Source: NCDM Disaster Database (http://camdi.ncdm.gov.kh/)[27])

3. Flood and Drought Monitoring and Forecasting in Cambodia

In Cambodia, Ministry of Water Resources and Meteorology (MoWRAM) is the mandated agency which directly engaged and deal with flood and drought monitoring, forecast and early warning. MoWRAM is designated National Meteorological and Hydrological Services (NMHS) in Cambodia. MoWRAM is the key producer of climate information in Cambodia. The Ministry of Agriculture, Fisheries, and Forestry (MAFF) is co-producer with value added information for agriculture and allied sectors. The National Committee for Disaster Management (NCDM) is also actively involved in flood and drought matters with the different mandate, roles and responsibilities. NCDM is mandated National Disaster Management Organisation (NDMO) in Cambodia. NCDM is also responsible for disaster management and impact assessment.

The MoWRAM and its two key departments including Department of Meteorology (DoM) and Department of Hydrology and River Work (DHRW) are principally involved with meteorological and hydrological observation, forecasting, and early warning, as well as matters related water resources management, including the construction of physical infrastructure and the provision of large-scale pumping equipment when required. The Department of Meteorology (DOM) provides forecasts for heavy rain and flash flooding and storms as well as temperature. The Department of Hydrology and River Works (DHRW) is the main agency responsible for flood forecasting. **Figure (11)** represents dissemination of hydro-meteorology forecasting and early warning information in Cambodia.

[27] NCDM (n.d.). Flood Disaster Database. URL: http://camdi.ncdm.gov.kh/

Section A: Introduction

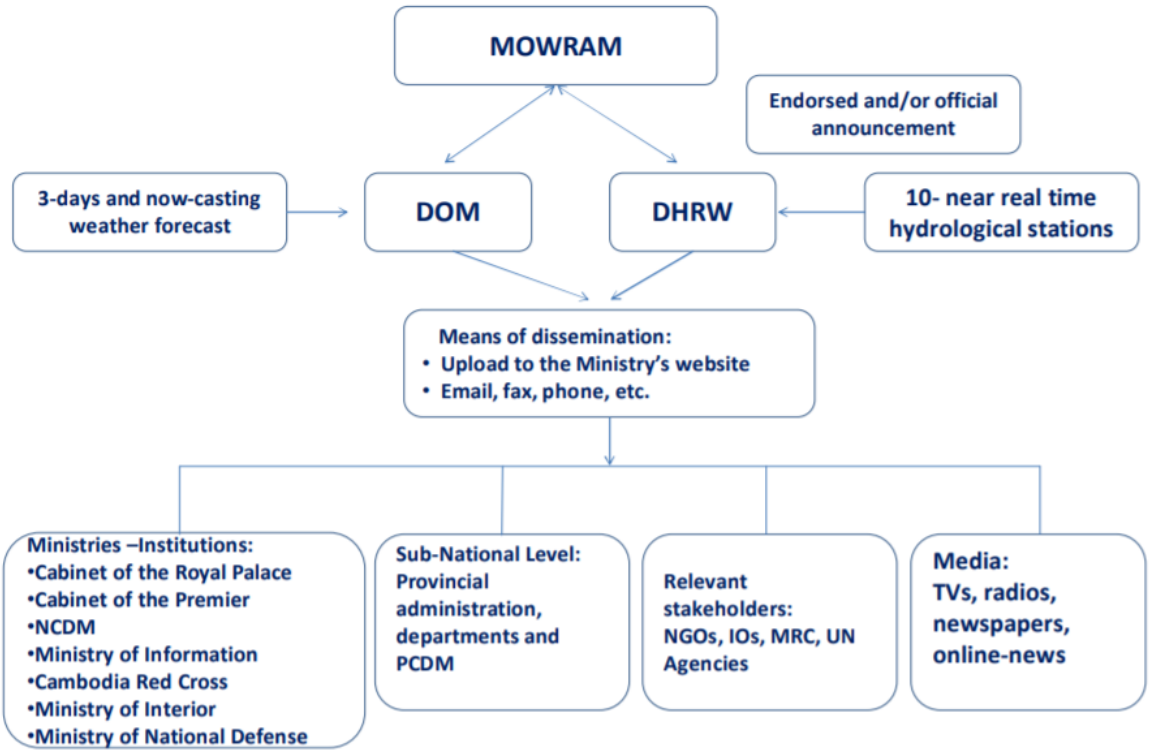


Figure (11): Dissemination of Forecasting and Early Warning Information in Cambodia (Source: MoWRAM, 2019)

The DoM established in year 1999 under the MoWRAM is mandated to provide weather services including drought and flood monitoring and forecasting for Cambodia (Dutta et al., 2015). DoM is responsible for the operation and maintenance of all the meteorological observation and measurements, issuance of weather forecasts and severe weather warnings all over the country (Dutta et al., 2018). The weather information linked to crop yield monitoring/forecasting is very important for farmers to take key decisions regarding the management of their crops, livestock, soil, harvest, and equipment. DoM regularly update about impending extreme events and its direct and indirect impacts through its Provincial Department of Water Resources and Meteorology (PDoWRAM).

Weather observation network in Cambodia is consists of synoptic stations with manned observational equipment and manual rainfall stations. In Cambodia, weather observation network including forecast tool consist of meteorological stations, manual weather stations, rain gauges, one S-Band Weather RADAR, GTS connection, high performance servers, and a HIMAWARI weather satellite data reception and visualization station; while the hydrological observation network consists of various stations. MoWRAM provides climate data and information; Nowcasting; three-day, one-week, and seasonal forecasts; and severe weather warnings as a public weather service. MoWRAM receives the various meteorological data /information as well as early warning for any impending extreme event that occurred in the region via the regional Global Telecommunication System (GTS) that linked from Thailand

Meteorological Department (TMD), Bangkok. The forecast and early warning is provided to many users such as local authorities, NCDM, MAFF, Ministry of Information, Ministry of Defense, Cambodia Red-Cross, Media (TV, Radio, newspaper, through fax, telephone, email, and website).

Department of Hydrology and River Work (DHRW) under MoWRAM, is responsible to manage and exchange hydrological information and issue forecasts and early warnings for possible floods and droughts to facilitate the timely adoption of mitigation measures. MOWRAM continuously engaged in the modernization of meteorological instruments and technology in Cambodia. The objective of this modernization is to enable the department to produce and broadcast weather forecasts to the relevant stakeholder. In this context, a Radar Station (TECHO SEN), has been established in Phnom Penh in year 2011. The station is operational since the April 2012 (http://www.cambodiameteo.com).

In terms of floods, the MoWRAM is in charge of pre-intervention measures such as early warnings, while the MAFF is in charge of post–intervention measures such as aiding with the restoration of rice fields following flood damage. The MoWRAM is also responsible for the establishment of Farmer Water User Committees (FWUCs), who are responsible for the management of water in their particular irrigation projects. A FWUC is not a government agency, but rather a group of stakeholders who live in the region where an irrigation scheme is located who came together to create the organization.

NCDM is another important government organization that deals with disaster management in Cambodia. Early warning and evacuation are the responsibility of the line authorities (Provincial, district, and Commune Committee for Disaster Management) within this organization. Despite the fact that Cambodia appears to have different government departments dedicated to drought relief, there is typically coordination among the many authorities involved. Also created to perform specialized duties are intergovernmental organizations (IGOs). So, for example, in order to investigate and deal with the effects of climate change, the government issued Sub–Decree Number 35 in 2006, which established the National Climate Change Committee, which is presided over by the prime minister, chaired by a minister from the Ministry of Environment, and comprised of other high–ranking officials from relevant government agencies as members. Following the issuance of the sub–decree, working groups and task forces were created to provide technical assistance to the National Committee. **Figure (12)** represent the organization structure of NCDM.

Section A: Introduction

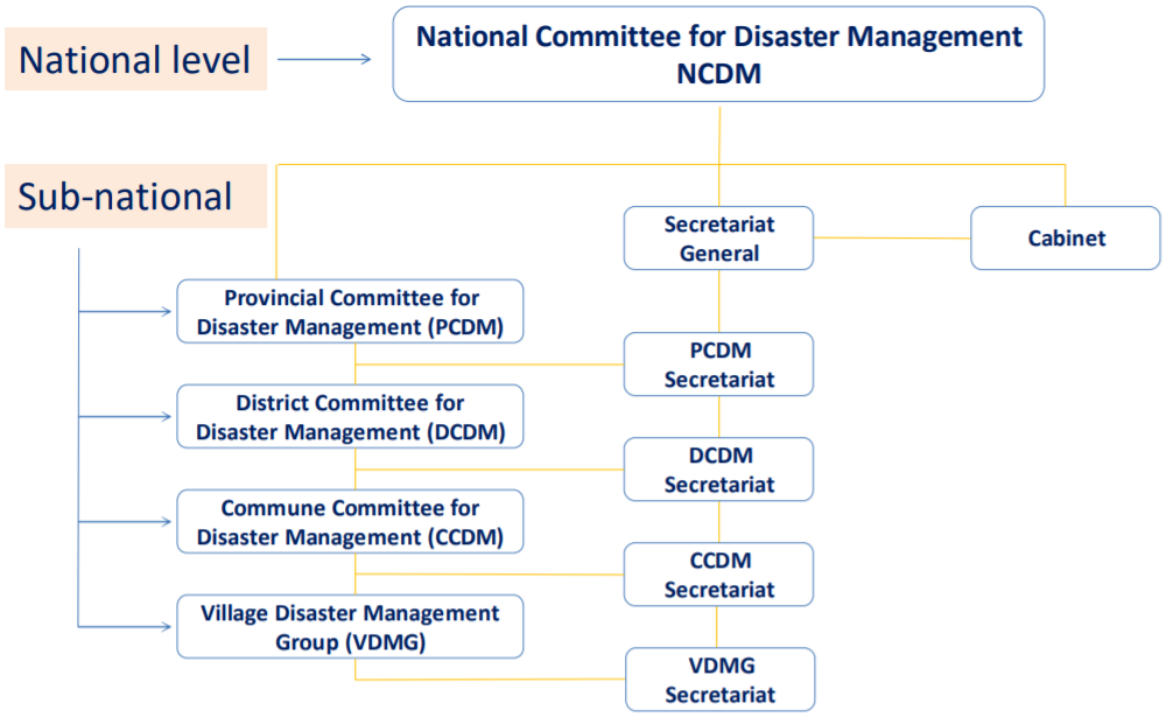


Figure (12): Organization Structure of NCDM (Source: Water Environment Partnership in Asia (2019))

In terms of warning generation and dissemination, an extensive review conducted for MoWRAM found that it is mandated to produce and disseminate forecasts for the entire country. Flood monitoring, forecasting and warning information on the Mekong, the Bassac and the Tonle Sap mainstreams is disseminated by the MoWRAM and the Department of Hydrology and River Works (DHRW). They disseminate information through daily bulletins, emails and faxes to relevant line agencies, to be disseminated further to the public by radio, newspapers and public media networks. Department of Meteorology is responsible for monitoring the weather conditions in the country and region; for issuing weather forecasts and providing warnings on weather conditions to relevant agencies, including the NCDM, by phone, fax, email, web page, TV/radio, newspaper and SMS. The Provincial Department of Water Resources and Meteorology (PDoWRAM) at the local level further disseminates the warnings to communities (communes) through its networks by phone and radio-communication. On the other hand, NCDM provides a coordinating role in establishing and implementing early warning programmes as well dissemination of warning information. While MoWRAM acts as the source agency for observation, detection and warning formulation, the National Committee for Disaster Management (NCDM) remains as the central agency to disseminate the early warning information to the provincial committees for disaster management (PCDM), district committees for disaster management (DCDM), commune committees for disaster management (CCDM), the Cambodian Red Cross (CRC) and

subsequently to the other entities of the last mile communication that are coordinated for emergency operations and response towards the early warning (Dutta et al., 2015).

4. Multi-stakeholder Initiatives

4.1 Early Warning System (EWS) 1294

EWS 1294 is a new initiative in Cambodia established in 2017 which alerts the public in advance of natural disasters that may occur in Cambodia. EWS 1294 is designed and developed by People-in-Need (PIN) that has been handed over to NCDM who now manages and operates the system (**Figure (13)**). Short code 1294 is a phone number that belongs to National Committee for Disaster Management (NCDM), given by Ministry of Posts and Telecommunications (MoPTC) and Telecommunication Regulator of Cambodia (TRC). An audio recording is delivered to the mobile phones of registered users in the affected areas when a natural disaster such as floods is detected or forecast, such as flash flooding. Three main mobile phone companies in Cambodia i.e. Smart Axiata Co., LTD; CamGSM. Co., LTD or called Cellcard and Metfone, provide its services for free for warning system and humanitarian purposes.

Figure (13) represents EWS 1294 platform.

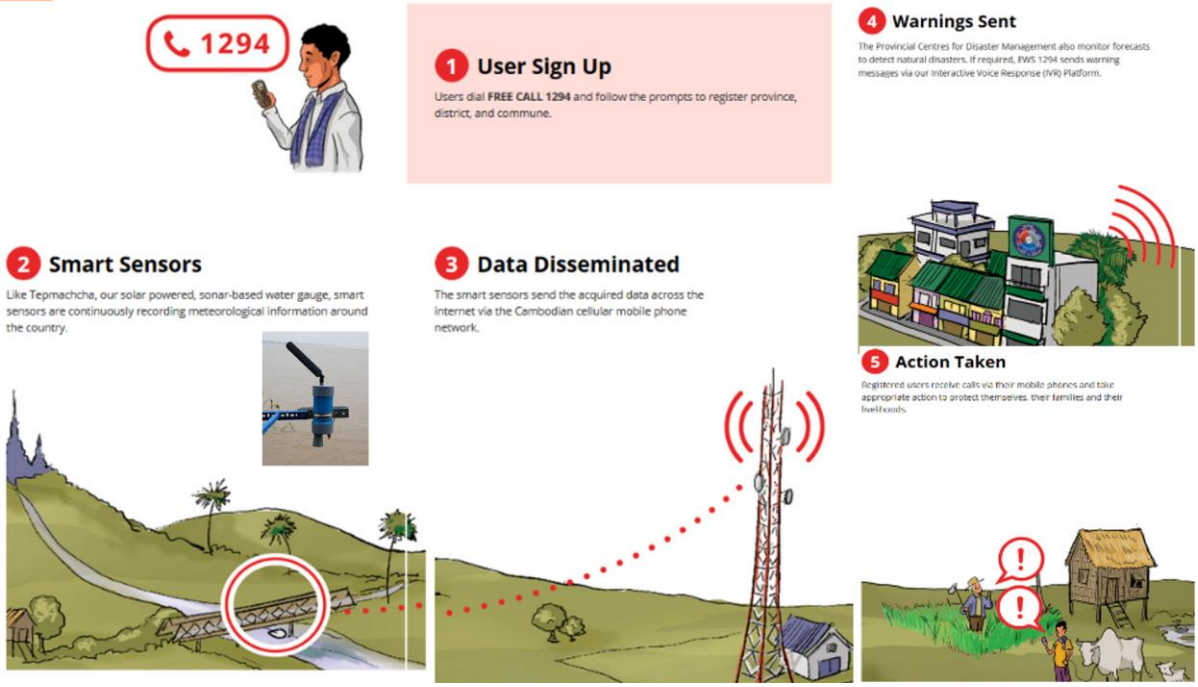


Figure (13): EWS 1294 Platform (Source: http://ews1294.info/en/how-it-works/)

5. Flood and Drought Impact Assessment in Cambodia

5.1 Disaster Data Collection

NCDM developed a disaster management guideline[28] in Cambodia for the collection of disaster loss and damage data (using reporting forms) and the communication of disaster (including drought) through the Commune Committee for Disaster Management (CCDM), District Committee for Disaster Management (DCDM), and Provincial Committee for Disaster Management (PCDM). The commune committee must report to the district about a disaster occurring within their administrative boundary using the forms provided, while the district committee monitors the situation and takes emergency response action, and then collects information for subsequent reporting purposes until the disaster has been resolved completely. The reporting is done to PCDM which in turn sends the information to NCDM.

The report from CCDM and DCDM consists of the following points:

- *Type of disaster, time of occurrence, status and current state*
- *Location and vulnerable population, evaluation of safe areas*
- *Situation/shortage of people 'In' and 'Out' of the safe areas*
- *Causality (death, injure, missing), impacts and damage on different sub-sectors*
- *Emergency assistance received*
- *Statement on priority need, summary of action up to date and*
- *Assessment/conclusion on disaster impact.*

The objectives of the data collection forms are to a) allow stakeholders at the sub-national level to record/enter assessment and evaluation data or figures already agreed upon, in order to submit to the national level in a timely and clear manner (consistency) b) help leadership of the Royal Government/ ministries/agencies to make quick and informed decision on immediate, timely and effective measures and interventions c) allow stakeholders/donors to consider providing appropriate humanitarian assistance to victims and rehabilitation, recovery and reconstruction assistance and d) reduce time wastage and overlapping uses of resources, as well as the suffering of victims, and allow for timely and effective interventions and better and stronger cooperation among all stakeholders at national and international levels. Ministry of Agriculture, Forestry, and Fisheries (MAFF) also collect and collate the drought impact data on agriculture. Impacts of drought on agriculture is reporting from local level to the national level. In this process District Department of Agriculture (DDA) send reports to Provincial Department of Agriculture, Forestry, and Fisheries (PDA) and PDAs send these reports to MAFF. At national level, MAFF consolidate all drought impact reports that received from all

[28] Guideline for Implementation of the Disaster Data Reporting Forms (2014). URL: https://www.kh.undp.org/content/cambodia/en/home/library/environment_energy/guideline-for-implementation-of-the-disaster-data-reporting-form.html

PDAs in term of area affected and area damage from drought. In Cambodia, drought impact has been expressed in term of water shortage and crop damages. After prediction by MoWRAM on drought condition, government institutions and relevant ministries prepared material, tool and equipment for response action. When drought happens, the government institutions and relevant stakeholder carried out the following response action:

- Declaration on disaster situation and appeal all stakeholder to keep monitor situation closely and update situation for post drought activity and take necessary action.
- The NCDM worked closely with concerned government institutions, UN agencies as well as other NGOs/INGOs and humanitarian forums and played a key role in coordinating the response.
- The local authorities, the Cambodian Red Cross (CRC) and NGOs have helped people distributing assistance to people in drought-affected areas.
- Helping farmer in providing water harvesting measures to help irrigated their rice crops during the drought period

5.2 Disaster Data Archiving and Analysis

5.2.1 Cambodia Disaster Damage & Loss Information System (CamDi)

Cambodia Disaster Damage & Loss Information System (CamDi) is national level system to collect, store and analyse disaster loss and damage data, and to improve understanding of risks and vulnerabilities in Cambodia. CamDi is developed by NCDM with the assistance of UNDP, UNDRR, LARED, OSSO, RobotSearch and Apache Software Foundation. CamDi is linked with DesInventar, which is a conceptual and methodological tool for the generation of National Disaster Inventories and the construction of databases of damages, losses and in general the effects of disasters. **Figure (14)** represents Cambodia Disaster Damage & Loss Information System (CamDi) tool.

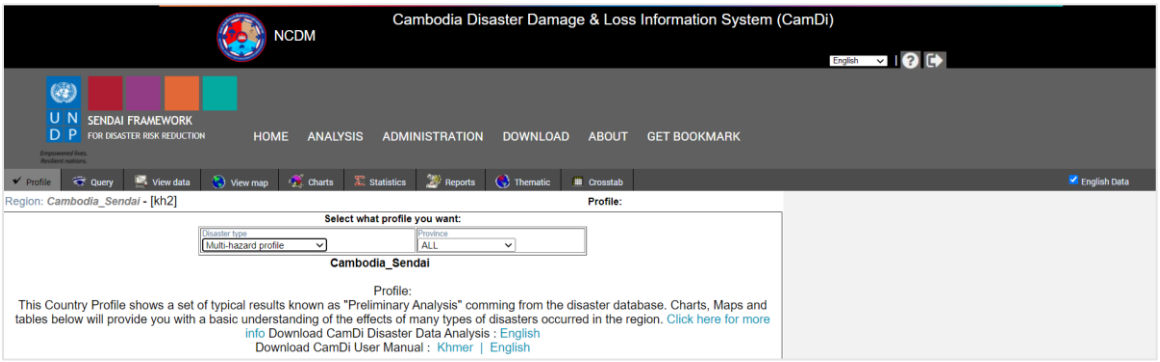


Figure (14): Cambodia Disaster Damage & Loss Information System (CamDi) (Source: CamDi (2021)[29])

[29] CamDI (n.d.). URL: http://camdi.ncdm.gov.kh/DesInventar/profiletab.jsp?countrycode=kh2&continue=y

5.2.2 Platform for Real-time Impact and Situation Monitoring (PRISM)

In order to monitor the risk and impact of climate hazards in real time, the Platform for Real-time Impact and Situation Monitoring (PRISM)[30] has been developed. For the first time, PRISM integrates satellite and other remote sensing data of climate-related hazards with data on socio-economic vulnerability to provide actionable climate risk information that helps those in need first. Droughts and floods, among other hazards , can be tracked over time using the maps' interactive features. Calculating the hazard's severity by administrative area is made easier with the use of graphs and tables (such as provinces and districts). Risk and effect indicators based on known vulnerabilities and exposure to hazards at any given time can also be generated automatically by the system. Mobile data collecting systems can be used in conjunction with PRISM. This gives customers the ability to see real-time data from affected locations, as well as hazard information supplied by the platform itself (PRISM, n.d.[30]). **Figure (15)** represents Platform for Real-time Impact and Situation Monitoring (PRISM) Tool.

Figure (15): Platform for Real-time Impact and Situation Monitoring (PRISM) Tool (Source: PRISM, n.d.[30])

5.2.3 Risk Assessment Initiatives in Cambodia

ADPC conducted Natural Hazard Risk Assessment for Cambodia in 2014, which is a comprehensive risk assessment in terms of damages and human losses, physical properties, and fiscal impacts on national economy due to the identified hazards of typhoons, droughts, floods and epidemics. The consequences of these natural hazards have been probabilistically characterized with indications of uncertainty. The risks are depicted as overall and disaggregated administratively, geographically, by sectoral elements of the built and natural environment as appropriate to serve governmental agencies' needs. The input data, and

[30] PRISM. URL: https://www.prism-kh.info/about

intermediate and final results have been compiled in analytical and geospatial formats, permitting applications of governmental agencies and others to derive results specific to their needs. **Figure (16)** shows the national and provincial risk assessment atlas developed by ADPC with support from the World Bank in 2014

Figure (16): National and Provincial Risk Assessment Atlas developed by Asian Disaster Preparedness Center (ADPC) in 2014

6. Key Development Agencies in Cambodia

Many international development organizations, such as the World Bank, Asian Development Bank (ADB), World Meteorological Organisation (WMO), Food and Agriculture Organisation (FAO), World Food Programme (WFP), Japan International Cooperation Agency (JICA), Korea International Cooperation Agency (KOICA), Swiss Agency for Development and Cooperation (SDC), Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) and Agence Française de Development (AFD) are involved in various flood and drought management projects in Cambodia by providing financial and technical support to relevant ministries and agencies such as MOWRAM, MAFF and NCDM etc. **Figure (17)** shows the list of development partners who are supporting different activities on droughts and floods in Cambodia.

Hazard Type	Level	Development Partners	Producer	Co-producer	User
Flood	Regional	The World Bank, ADB	Mekong River Commission (RFDMC)		
	National	The World Bank, ADB, JICA, UNDP, UNESCAP		MOWRAM, (DOM/DHRW) NCDM	NCDM
	Sub-national/Local	INGO/NGO			PCDM/DCDM/CCDM; Ministry of Agriculture, Forestry and Fisheries, Department of (Agriculture), Other Provincial Government Department; Municipalities
Drought	Regional	The World Bank, ADB, FAO, WFP, UNESCAP	Mekong River Commission (RFDMC)		
	National	The World Bank, ADB, FAO, WFP, JICA, UNDP		MOWRAM, (DOM/DHRW) NCDM	NCDM
	Sub-national/Local	INGO/NGO			PDCM/DCDM/CCDM Ministry of Agriculture, Forestry and Fisheries, (Department of Agriculture); Other Provincial Government Department; Municipalities
Cyclone/Typhoon	Regional	The World Bank, ADB, UNESCAP Typhoon Committee	RSMC (WMO), JTWC, ASMC		
	National	The World Bank, ADB, JICA, UNDP		MOWRAM (DOM) NCMD	NCDM
	Sub-national/Local	INGO/NGO			PCDM/DCDM/CCDM Other Provincial Government Department; Municipalities

Figure (17): List of development partners who are supporting different activities on droughts and floods in Cambodia

7. New Initiative

World Meteorological Organization (WMO) led the Climate Risk and Early Warning Systems (CREWS) Initiative launched a new initiative in Cambodia and Lao PDR on **05th October 2021.** The four-year, $5.5 million initiative will help vulnerable communities in Cambodia and Lao PDR by improving hydrometeorological, early warning, and response capabilities (CREWS, 2021). WMO, UNDRR, and the World Bank Global Facility for Disaster Reduction and Recovery (GFDRR) are supporting these initiatives. The project is expected to complete by July 2025. The project also banks on existing regional efforts and actively engages regional stakeholders. During the project duration, both NMHSs and NDMOs of Cambodia and Lao PDR will be engaged to identify the gaps in existing Multi Hazard Early Warning Systems (MHEWS) and address them by linking it to the four pillars of MHEWS including risk knowledge, monitoring and warning services, dissemination and communication, and response capability (WMO, 2021[31]).

8. Summary

- In Cambodia, at national level, DOM and DHRW under MoWRAM are mandated to produce and disseminate weather forecasts and warnings for the entire country.

[31] WMO (2021). URL: https://public.wmo.int/en/media/news/enhancing-early-warning-systems-cambodia-and-lao-people%E2%80%99s-democratic-republic

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- Provincial Department of Water Resources and Meteorology (PDoWRAM) at sub-national level have very limited capacity and technology to produce the weather forecasts or even value add to information from national level. PDoWRAM receive the information from MoWRAM (DHRW and DOM) and further disseminate the forecasts and warnings to communities through their networks including phone, radio-communication.
- NCDM and its line agencies such as PCDM, DCDM and CCDM play an important role in disseminating weather forecasts to the communities. NCDM also plays an important role in collecting, storing and analyzing disaster loss and damage data.
- In changing climatic conditions, existing capacities at MoWRAM and PDoRAM will not suffice, due to unpredictability and increasing severity of extreme weather events clearly require significant improvement in the capacity for early warning and preparedness.
- Lack of trained human resources, lack of sufficient funding, outdated communication systems, and lack of equipment are key concern of stakeholders.
- Cambodian agricultural sector is still facing a number of challenges, including low productivity, limited supporting infrastructure, supporting technologies and techniques for agro-industry, inconsistent supply of agriculture produces in terms of both quantity and quality, inadequate access to markets and price fluctuation, and climate change, amongst others. Existing technical capacities at MAFF needs enormous improvement especially use of remote sensing, GIS technology and development of decision support system.
- There is need of impact-based forecasting by linking efforts of MoWRAM and NCDM in Cambodia.

SECTION

B

APPROACH AND METHODOLOGY

SECTION B | Approach and Methodology

1. Background

A simplified rendition of the overall approach and methodology is presented in this section of the report. Various key elements of the Impact based Forecast and Warning (IbFW) readiness assessment were first outlined and defined and then a phase-wise procedure followed to achieve overall objective described in Terms of Reference (ToR). The methodology designed and used for the readiness assessment was based on international best practices of IbFW assessment and was mindful of the operational constraints due to COVID-19, information/data requirements, availability, collection, collation, and further analysis. The approach and methodology are tailor made for Cambodia based on a wide range of discussion and existing secondary information and data and integrated them into a format that was discussed with client (i.e. WFP) and consultation with national stakeholders. A systematic process was adopted to assess the readiness on IbFW in Cambodia. IbFW readiness assessed, particularly with respect to the systems for hydro-meteorological hazards (mainly Floods, Cyclone, Drought) in Cambodia.

Figure (18) represents approach and methodology of the IbFW readiness assessment.

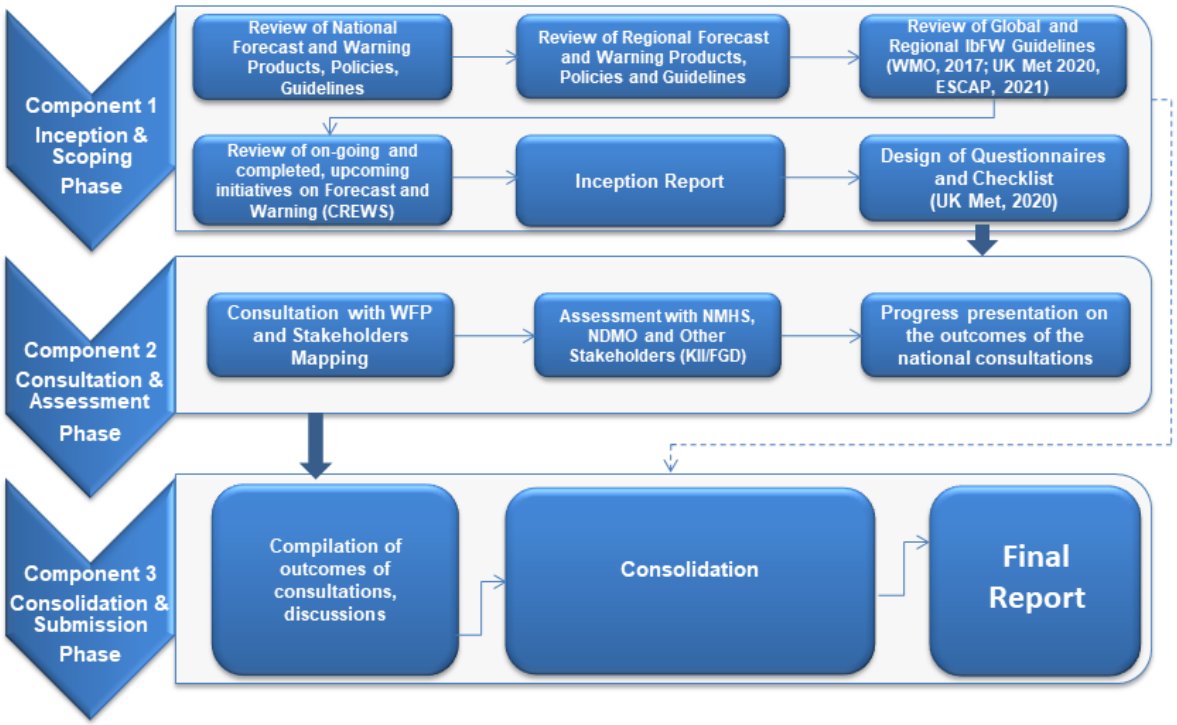

Figure (18): Approach and Methodology (Source: ADPC, 2022)

Natural hazards are becoming more and more intricate, complex and multi-faceted in the country. It is evident from previous studies and various assessments that the Lower Mekong Countries especially Cambodia are highly prone to various hydro-meteorological hazards

including floods, droughts, cyclones and lightning (ADPC, 2010). These countries are extremely vulnerable due to their unique geo-climatic setting in Southeast Asia.

NMHS in Cambodia is mandated and accountable to provide weather forecast as well as warning to disaster management institutions (NDMO), and other stakeholders such as agriculture and water resources agencies. NDMO and other technical stakeholders are also mandated and accountable to provide warning for dissemination, adding sector specific information, resource mobilization in the community, etc. Recognizing the fact that the frequency and severity of hydro-meteorological hazards is on the rise in changing climatic conditions, existing capacities of forecast and warning of NMHS need to be reviewed time-to-time. Unpredictability and increasing frequency of extreme hydro-meteorological events will clearly require significant improvement in the existing capacities of forecast and warning in near future linking with impacts on different elements (human, livestock, agriculture, key lifeline infrastructure, housing, business/livelihood) of society. Although, routine forecast and warning exist in this country, however to convert into impact-based forecast and warning, they require timely upgradation and modernization of tools, technology as well as hiring of well-trained human resources.

In IbFW readiness assessment, an attempt has been made to assess existing capacities and future needs related to IbFW of NMHSs, NDMO and other prioritized stakeholders in the project country. IbFW readiness (capacities and needs) of national level agencies have been assessed through Key Informant Interviews (KII) and Focus Group Discussions (FGD) using structured questionnaires.

IbFW readiness assessment involved a systematic flow of understanding the forecast and warning structure at the regional, national, sub-national and local levels. It include institutional mechanism and their roles within the elements of IbFW; delivery of products and services by technical and disaster management agencies, as well as their coordination mechanism/operational cooperation; reviewing of existing mechanism of IbFW in Cambodia; role of agencies in the IbFW and their integration in the disaster management organizations framework; discussion with stakeholders, the gaps and needs in the IbFW; capacities of institutions (technical agencies) engaged in IbFW; operational cooperation of technical agencies with the emergency departments/functionaries at the district and city levels (emergency management structure and response capabilities); current status and future needs of observation and monitoring capabilities; data management systems; seeking information on pre-computed assessment of risks for various intensity of hazards (risk assessment), hazard analysis and prediction capabilities (threat assessment/potential impact assessment); warning formulation/issuance of guidance and potential outlook/provision of actionable early warning information/warning products; decision making, generation of tailored risk information and

dissemination of risk information to at-risk communities or hot-spot locations (risk communication); information technology & telecommunication capabilities; preparation of response options; and institution/emergency responders & community response.

2. Reference Document

A number of IbFW guidelines have been developed in recent years by number of agencies such as WMO (2015), UK Met (2020) and UNESCAP (2021). The readiness assessment process has referred to a range of documents developed by these international and regional agencies.

Figure (19) represents international and regional guidelines on IbFW.

Source: WMO (2015) | Source: MET Office, UK (2020) | Source: UNESCAP (2021)

Figure (19): International and Regional Guidelines on IbFW

3. IbFW Readiness Assessment Matrix

IbFW readiness has been assessed based on an assessment matrix. This assessment matrix was developed by the ADPC technical team based on three primary components i.) Co-design, ii) Co-produce and iii) Deliver. These three primary components of IbFW are suggested in guidelines developed by World Meteorological Organization (2015) and UK Met (2020). Further these primary components were divided into secondary or sub-components of IbFW.

The brief description of the component and sub-component is given below **Table (2).**

Table (2): Key Component of IbFW	
Component	**Sub-components**
Co-design	Understanding about IbFW
	Stakeholder mapping and assessment of IbFW understanding level

Section B: Approach and Methodology

Co-produce	Understanding Risk and impact assessment
	Understanding IbFW Generation
Deliver	IbFW Dissemination
	Forecast/Impact Verification

During consultation, ADPC used 58 main questions and 20 sub-questions for IbFW readiness assessment. These questions were added into matrix which was designed and developed based on key guiding questions and methodology provided in IbFW guidelines developed by UK Met (2020). These questions were translated into local language for ease of doing survey and further assessment.

Figure (20) represents IbF approach and methodology.

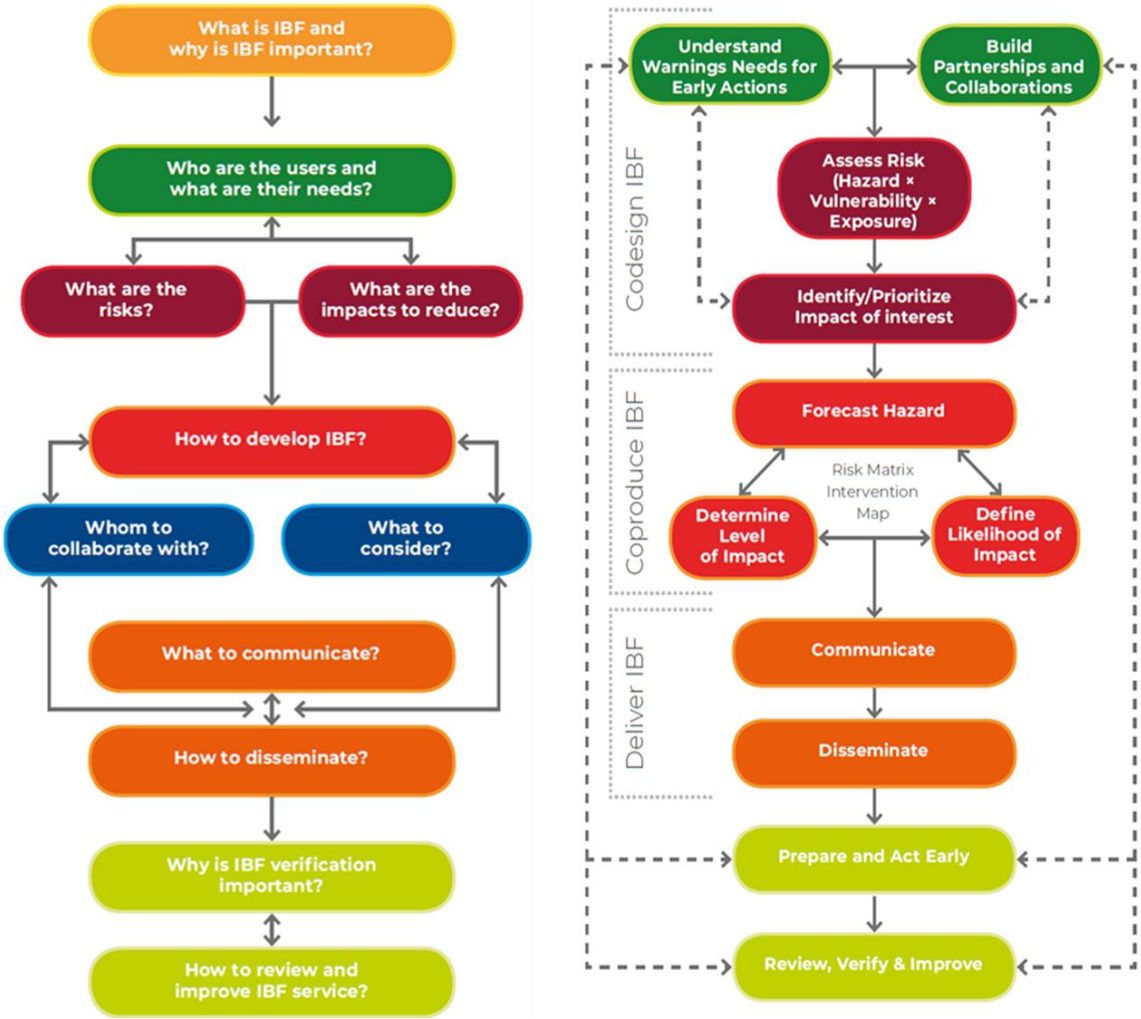

Figure (20): IbF Approach and Methodology (Source: UK Met., 2020)

Section B: Approach and Methodology

4. Ranking

Post consultation (KII and FGD), IbFW readiness have been assessed through a scoring system ranging from 0-5 with inputs from key representative and technical officials from NMHS (MoWRAM), NDMO (NCDM) and other stakeholders (MAFF) in Cambodia. The scores were assigned by the subject experts based on their experiences, perceptions and opinions on existing IbFW at the national level in Cambodia. The brief description of the scoring system is given below **Table (3).**

Table (3): Scoring system with the scale definitions

Score	Levels	Scale definition
1	Very Low	Very Low Understanding and Capacity
2	Low	Low Understanding and Capacity
3	Medium	Medium Understanding and Capacity
4	High	High Understanding and Capacity
5	Very High	Very High Understanding and Capacity
Source: Dutta et al., 2015[32]		

It is very essential that three component and their sub-components of IbFW coordinated across many agencies at national to local levels for entire system to work. Failure in one component or lack of coordination across them could lead to the failure of the whole system. The issuance of forecast and warnings is a national responsibility of NMHS; thus, roles and responsibilities of various other stakeholders for implementation of IbFW need to be clarified and reflected in the national to local regulatory frameworks, planning, budgetary, coordination, and operational mechanisms. MHEWS assessment was carried out with the national organizations. **Table (4)** represents list of stakeholders surveyed in the Cambodia.

Table (4): List of Stakeholders Surveyed in Cambodia

Date	Agency	Representative Expert/Specialist
04 January 2022	Department of Meteorology, Ministry of Water Resources and Meteorology (MoWRAM), Royal Government of the Kingdom of Cambodia	Mr. OUM Ryna, Director of Department of Meteorology
11-13 January 2022	National Committee for Disaster Management	H.E Seng Samban, Advisor to NCDM; Mr. Mao Saohorn, Deputy Director DoEAT/NCDM;

[32] https://pdfs.semanticscholar.org/d98a/e6bcc548ad3ad7168a821ddf5d16d0b0daf4.pdf

Table (4): List of Stakeholders Surveyed in Cambodia		
Date	**Agency**	**Representative Expert/Specialist**
	(NCDM), Royal Government of the Kingdom of Cambodia	Mr. Mam Phalla, Deputy Director DMinfo/NCDM
14 January 2022	Ministry of Agriculture, Forestry and Fisheries (MAFF)	Mr. Soeun Mak, Deputy General Director, General Directorate of Agriculture (GDA); Dr. Minea Mao, Director Department of Agricultural Extension

5. Limitations

The findings of this study have to be seen in light of some limitations and that could be addressed in future projects in the Southeast region.

- ADPC technical team members were not able to travel Cambodia, due to COVID-19 related travel restrictions. Keeping the travel restrictions and time constraints, ADPC completed all regional and national consultations in hybrid mode;
- Due to COVID-19 related travel restrictions, all consultations were conducted by national staff, especially in a form of Key Informant Interviews (KII) and Focus Group Discussions (FGD) with MoWRAM, NCDM and MAFF. Necessary training was provided to national staff.
- The study originally planned in-country consultations and discussions with certain organizations and people (in KII and FGD mode). Due to the pandemic, ADPC technical team faced the problem of having limited access to these respondents. Due to this limited access, ADPC technical team redesigned/restructured the consultation and discussion approaches and methods through an online format of assessment followed by a virtual mode of consultations with relevant stakeholders. This engagement has ensured that feedbacks are appropriately received and the assessment results have been verified;
- ADPC technical team were only able to consult and discuss with nominated representatives of MoWRAM, NCDM and MAFF. In normal conditions, ADPC technical team would have allocated a full day or two for the discussions to conduct such assessment in KII and FGD mode;
- Verification of views and inputs are very crucial in qualitative assessment. There was limited opportunity to physically verify the views and inputs from representative respondents of MoWRAM, NCDM and MAFF on IbFW readiness assessment;
- There was no opportunity to discuss with other stakeholders such as development partners, INGOs/NGOs/CBOs or communities in Cambodia as the assessment had to be carried out virtually due to the COVID-19 travel restrictions and with most agencies working remotely and so was the difficulty in getting in touch with these agencies. Inability to conduct in-person assessment limited us to include all stakeholders to take the assessment;

- There was no opportunity to take field notes and review key documents such as past/ongoing project reports, polices, acts, guidelines, plans which were neither available in digital format nor available online;
- There was no opportunity to capture some traditional knowledge of communities on early warning in Cambodia;
- There was no opportunity to observe the IbFW infrastructure (including tools and technology) in physical conditions.

SECTION

C

RESULTS AND DISCUSSION

SECTION C | Result and Discussion

C.1 | Cambodia

1. Overall Assessment:

In Cambodia, at national level Department of Meteorology (DOM) and Department of Hydrology and River Works (DHRW) of MoWRAM are mandated to produce and disseminate traditional weather forecasts and warnings for the entire country. Provincial Department of Water Resources and Meteorology (PDoWRAM) at sub-national level have very limited capacity and technology to produce the weather forecasts or even add value to information from national level. PDoWRAM receive the information from MoWRAM (DHRW and DOM) and further disseminate the forecasts and warnings to communities through their networks including phone and radio-communication. NCDM on the other hand, together with its line agencies such as PCDM, DCDM and CCDM, plays an important role in disseminating weather forecasts to the communities. In changing climatic conditions, existing capacities at MoWRAM and NCMD will not suffice, due to unpredictability and increasing severity of extreme weather events that clearly requires significant improvement in the capacity for early warning and preparedness. Lack of trained human resources, in-sufficient funding, outdated communication systems, and lack of equipment are key concern of stakeholders. Cambodian agricultural sector is still facing a number of challenges, including low productivity, limited supporting infrastructure, supporting technologies and techniques for agroindustry, inconsistent supply of agricultural produces in terms of both quantity and quality, inadequate access to markets and price fluctuation, and climate change, amongst others. Existing technical capacities at MAFF needs enormous improvement especially on the use of remote sensing, GIS technology and development of decision support system for effective crop monitoring and potential yield forecasting. Lack of multi-agency coordination system is another area that will require focus. Coordination among multi-agencies during disaster (floods/drought/cyclones/etc.) collaboration forms a key issue due to the various challenges faced when there is interaction between agencies. A key challenge is the interaction between communities and authorities as well as a lack of understanding of agencies' contributions in terms of what they can and cannot do, and also what resources they possess. Different organizational cultures also produce several collaboration problems due to incompatible procedures, processes, and a lack of understanding of concepts (thus creating inter-organizational challenges).

The overall IbFW readiness assessment in Cambodia was carried out based on six key areas that includes:

i. Level of Understanding about IbFW
ii. Stakeholder Mapping and Assessment of IbFW Understanding Level
iii. Risk and Impact Assessment

Section C: Results and Discussions

iv. IbFW Generation
v. IbFW Dissemination
vi. Forecast/Impact Verification

While (i) and (ii) has been categorized as Codesign Phase, (iii) and (iv) has been categorized as Coproduce Phase and (v) and (vi) has been categorized as Delivery Phase (**Figure (21)**).

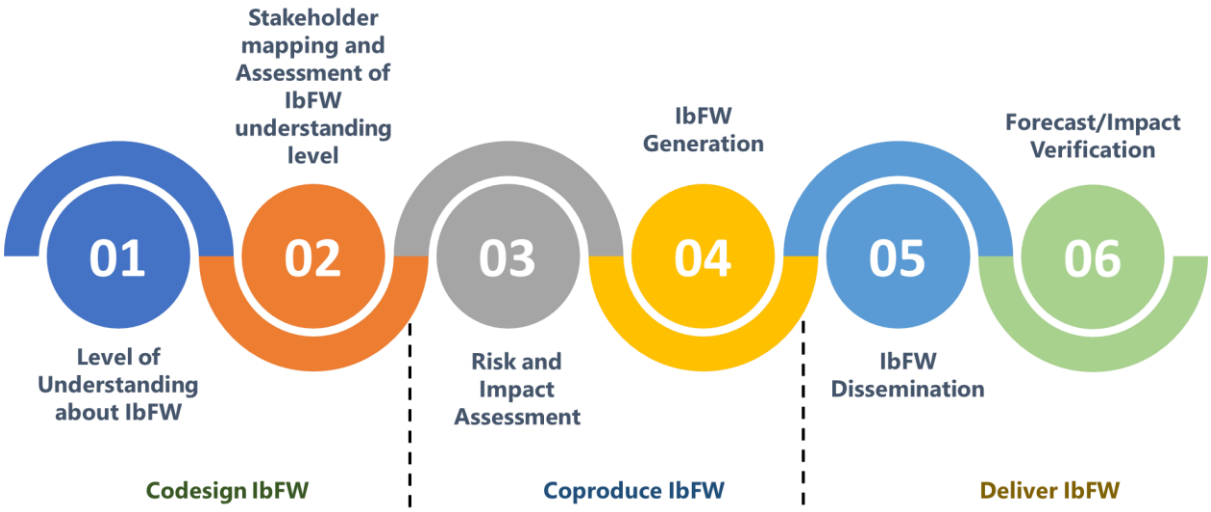

Figure (21): Key Areas Considered for IbFW Readiness Assessment in Cambodia.

The overall assessment results in the **codesign phase of IbFW** have shown that the level of knowledge and understanding about IbFW in Cambodia is medium (**Score of 3.0**) meaning there exist awareness about IbFW among the targeted agencies (DOM/MoWRAM, NCDM and MAFF). Similarly, in terms of stakeholders mapping and assessment of IbFW understanding level, once again the overall assessment result was found to be medium (**Score of 3.0**) with three agencies identifying relevant partners such as the UNDP, WFP and People in Need (PIN) while also acknowledging that the stakeholders may have medium level of understanding on IbFW. Most of the engagements with development partners are project-based partnerships and collaborations. However, the overall results do not identify any other additional stakeholders.

The overall assessment results in the **coproduce phase of IbFW** have shown that the targeted agencies have low level knowledge and understanding of risk and impact assessment as well as IbFW generations (**Score of 2.0**). All three agencies have confirmed that national level risk assessment was not done, however, small scale assessments may have been done at provincial or district levels. In terms of forecast and warning generation, all the three agencies (DOM, NCDM, MAFF) have responded by saying that the current hazard forecast and warning information are being issued only for key hazards that includes floods, droughts, storms and lightning and such information are available on a daily and weekly basis. However, the integration of IbFW is lacking.

Section C: Results and Discussions

The overall assessment results in the **delivery phase of IbFW** have shown that the targeted agencies have low level knowledge and skills in IbFW dissemination and forecast verification (**Score of 2.0**). While DOM/MoWRAM is responsible for issuing forecast and warning information, the information sent out to NCDM and MAFF are still based on traditional weather forecasting and therefore, both these agencies receive information on weather conditions which are generic and does not clearly reflect the area of impact and its likely intensity. There are also other factors which further supplement to the existing challenges that includes limited knowledge of stakeholders in understanding the existing forecast and warning information in response to the hazard's occurrence, limited understanding of the required actions on preparedness at local level/end user level after the warning or forecast is issued and lack of interagency coordination mechanisms. **Figure (22 and 23)** shows the overall IbFW Readiness in Cambodia.

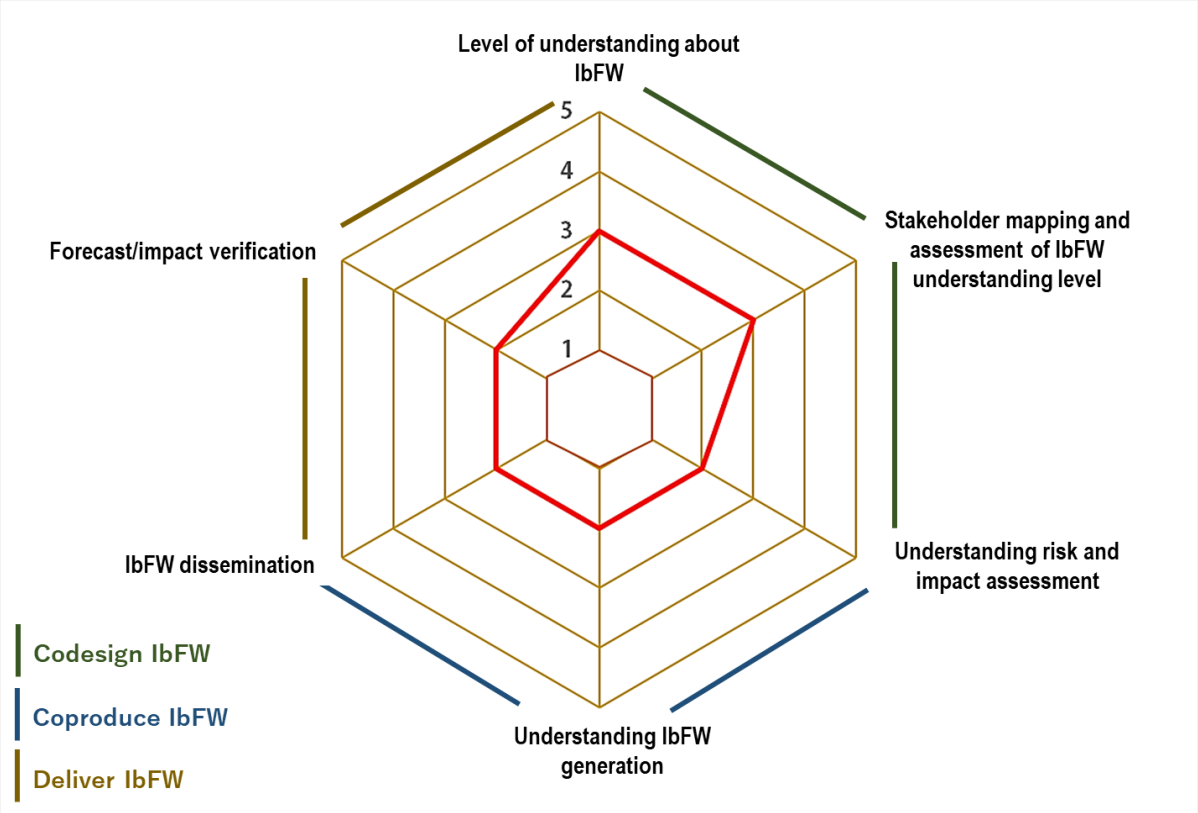

Figure (22): Overall IbFW Readiness in Cambodia. (Scale: 1-Very Low (Very low understanding and capacity); 2-Low (Low understanding and capacity); 3-Medium (Medium understanding and capacity); 4-High (High understanding and capacity); 5-Very High ((Very high understanding and capacity)

The assessment outcomes have suggested that existing capacities at MoWRAM and PDoRAM will have to be further enhanced to enable them strengthen their early warning capacity through trained human resources, adequate funding, improved communication system and updated

technologies. Adoption of appropriate agricultural practices and support to enhance infrastructure and technologies would improve not only productivity but would also strengthen their marketing abilities and improved pricing of their products.

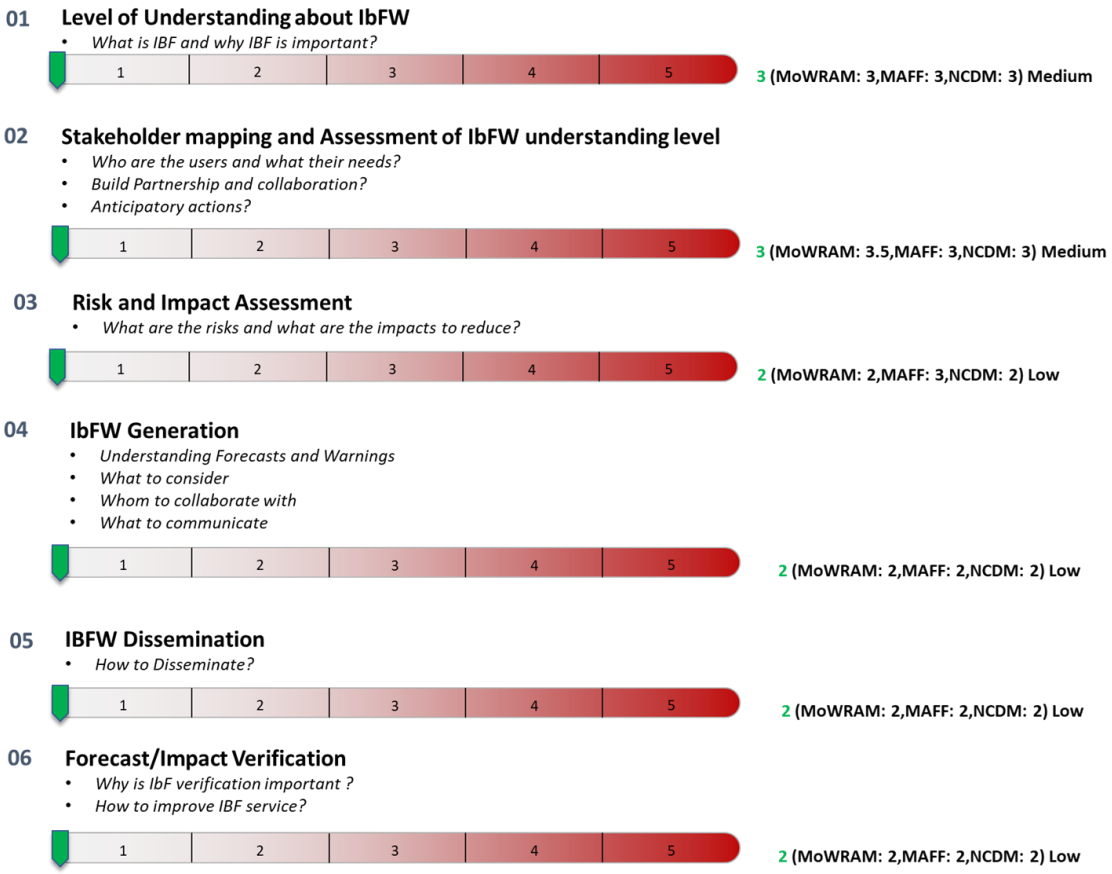

Figure (23): Overall IbFW Readiness in Cambodia based on the overall scores from the agencies. (Scale: 1-Very Low (Very low understanding and capacity); 2-Low (Low understanding and capacity); 3-Medium (Medium understanding and capacity); 4-High (High understanding and capacity); 5-Very High ((Very high understanding and capacity)

2. Agency-wise Assessment:

2.1. Department of Meteorology (DOM)

The overall assessment results in the **codesign phase of IbFW** have shown that the level of knowledge and understanding about IbFW within DOM is medium (**Score of 3.0**) meaning there exist awareness about IbFW. Similarly, in terms of stakeholders mapping and assessment of IbFW understanding level, the overall assessment result was found to be slightly higher than medium (**Score of 3.5**) with DOM working very closely with UNDP. Most of the engagements with development partners are project-based partnerships and collaborations. However, DOM also has official mandates to engage with international agencies such as the WMO and others. The overall results do not identify any other additional stakeholders.

Section C: Results and Discussions

The overall assessment results in the **coproduce phase of IbFW** have shown that DOM have low level knowledge and understanding of risk and impact assessment as well as IbFW generations (**Score of 2.0**). DOM is not aware of any national level or pilot scale risk assessment being done in Cambodia. Similarly, in terms of forecast and warning generation, DOM issues forecast and warning information for key hazards in Cambodia that includes floods, droughts, storms and lightening and such information are generated on a daily and weekly basis. The information is then shared with NCDM for their awareness and dissemination. However, the integration of IbFW is lacking.

The overall assessment results in the **delivery phase of IbFW** have shown that DOM have low level knowledge and skills in IbFW dissemination and forecast verification (**Score of 2.0**). While DOM/MoWRAM is responsible for issuing forecast and warning information, the information received by NCDM and MAFF are more generic mostly focusing on weather condition and does not define the area of impact and its likely intensity. Therefore, DOM agree that IbFW would be very essential in improving the accuracy of information dissemination and warning. **Figure (24)** shows the overall IbFW Readiness of DOM/MoWRAM.

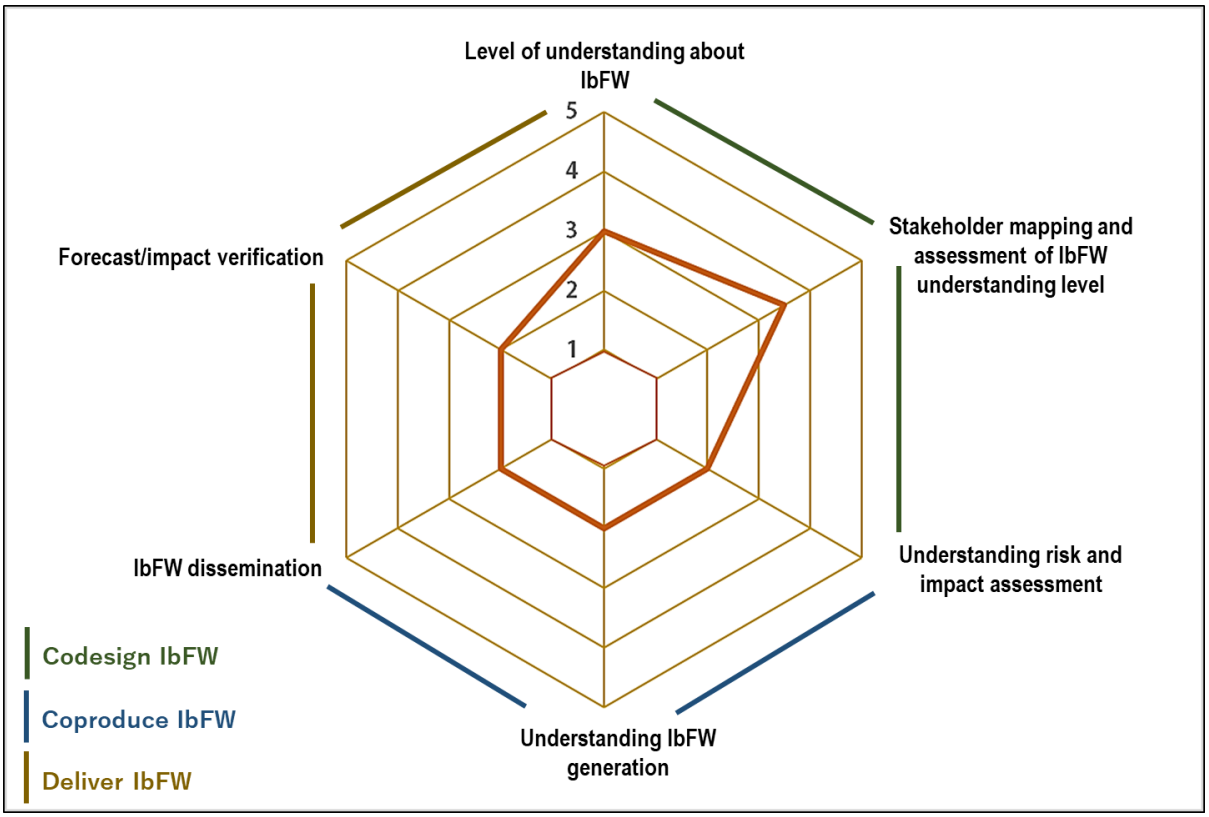

Figure (24): Overall IbFW Readiness within DOM. (Scale: 1-Very Low (Very low understanding and capacity); 2-Low (Low understanding and capacity); 3-Medium (Medium understanding and capacity); 4-High (High understanding and capacity); 5-Very High ((Very high understanding and capacity)

Section C: Results and Discussions

2.2. National Committee for Disaster Management (NCDM)

The overall assessment results in the **codesign phase of IbFW** have shown that the level of knowledge and understanding about IbFW within NCDM is medium (**Score of 3.0**) meaning there exist awareness about IbFW amongst its staff. Similarly, in terms of stakeholders mapping and assessment of IbFW understanding level, the overall assessment result was found to be medium (**Score of 3.0**) with NCDM working very closely with development partners such as UNDP, WFP and People in Need (PIN). Most of the engagements with development partners are project-based partnerships and collaborations. However, the overall results do not identify any other additional stakeholders.

The overall assessment results in the **coproduce phase of IbFW** have shown that NCDM's knowledge and understanding of risk and impact assessment as well as IbFW generations needs to be improved and enhanced (**Score of 2.0**). NCDM also highlighted that no systematic risk and impact assessments have been done at the national level or at national scale, but there has been some small-scale assessment conducted with development partners.

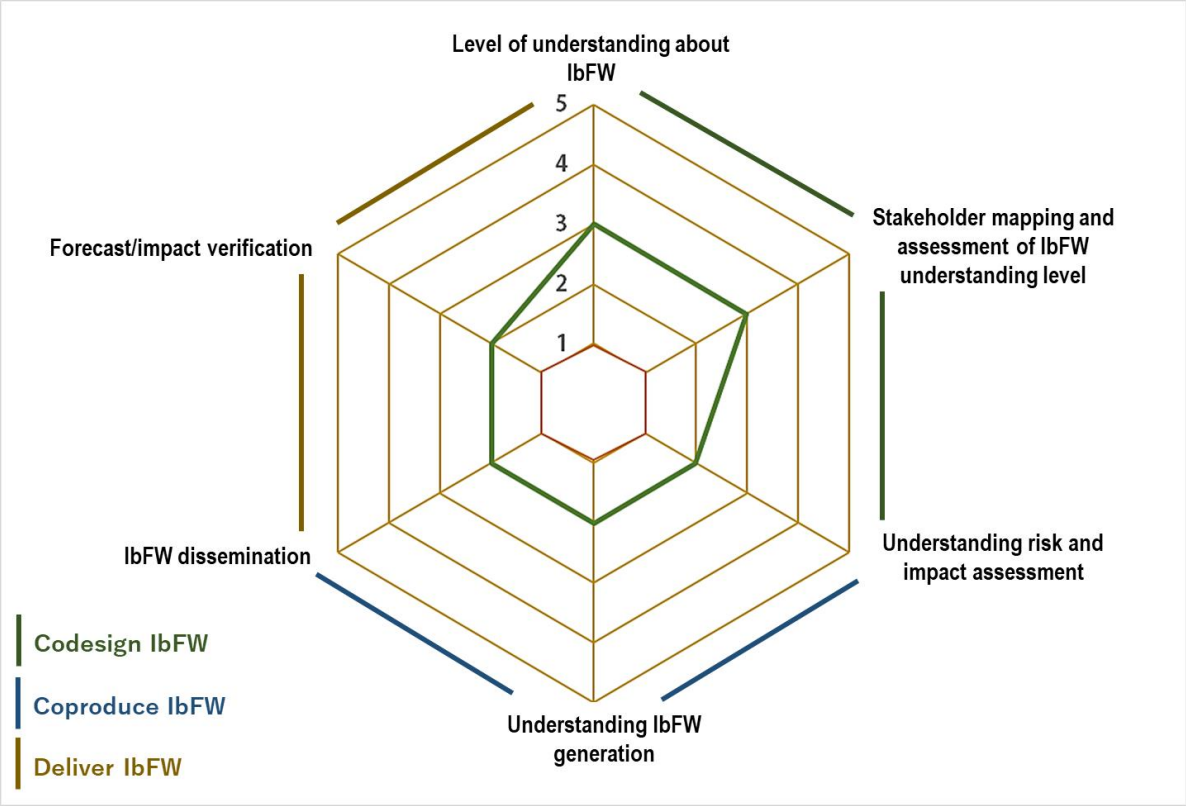

Figure (25): Overall IbFW Readiness within NCDM. (Scale: 1-Very Low (Very low understanding and capacity); 2-Low (Low understanding and capacity); 3-Medium (Medium understanding and capacity); 4-High (High understanding and capacity); 5-Very High ((Very high understanding and capacity)

Section C: Results and Discussions

The overall assessment results in the **delivery phase of IbFW** have shown that NCDM's knowledge and skills in IbFW dissemination and forecast verification can be improved (**Score of 2.0**). NCDM has also suggested that IbFW should be integrated in order for DOM to generate more improved forecast and warning information that would help in better planning and preparedness. **Figure (25)** shows the overall IbFW Readiness of NCDM.

2.3. Ministry of Agriculture, Forestry and Fisheries (MAFF)

The overall assessment results in the **codesign phase of IbFW** have shown that the level of knowledge and understanding about IbFW within MAFF is medium (**Score of 3.0**) meaning there exist awareness about IbFW amongst its staff. Similarly, in terms of stakeholders mapping and assessment of IbFW understanding level, the overall assessment result was found to be medium (**Score of 3.0**) with MAFF working very closely with development partners such as UNDP and WFP. Most of the engagements with development partners are project-based partnerships and collaborations. However, the overall results do not identify any other additional stakeholders.

The overall assessment results in the **coproduce phase of IbFW** have shown that MAFF have medium (**Score of 3.0**) level knowledge and understanding of risk and impact assessment but level understanding of IbFW generations (**Score of 2.0**). similar to NCDM, MAFF also highlighted that no systematic risk and impact assessments have been done at the national level or at national scale, but there has been some small-scale assessment conducted with development partners.

The overall assessment results in the **delivery phase of IbFW** have shown that MAFF have low level knowledge and skills in IbFW dissemination and forecast verification (**Score of 2.0**) as it is not within their scope of work. MAFF gathers the information and available bulletins from the official websites of MoWRAM and NCDM for planning and decision-making purposes. No direct forecast and advanced information are received from NCDM and MoWRAM. **Figure (26)** shows the overall IbFW Readiness of MAFF.

Section C: Results and Discussions

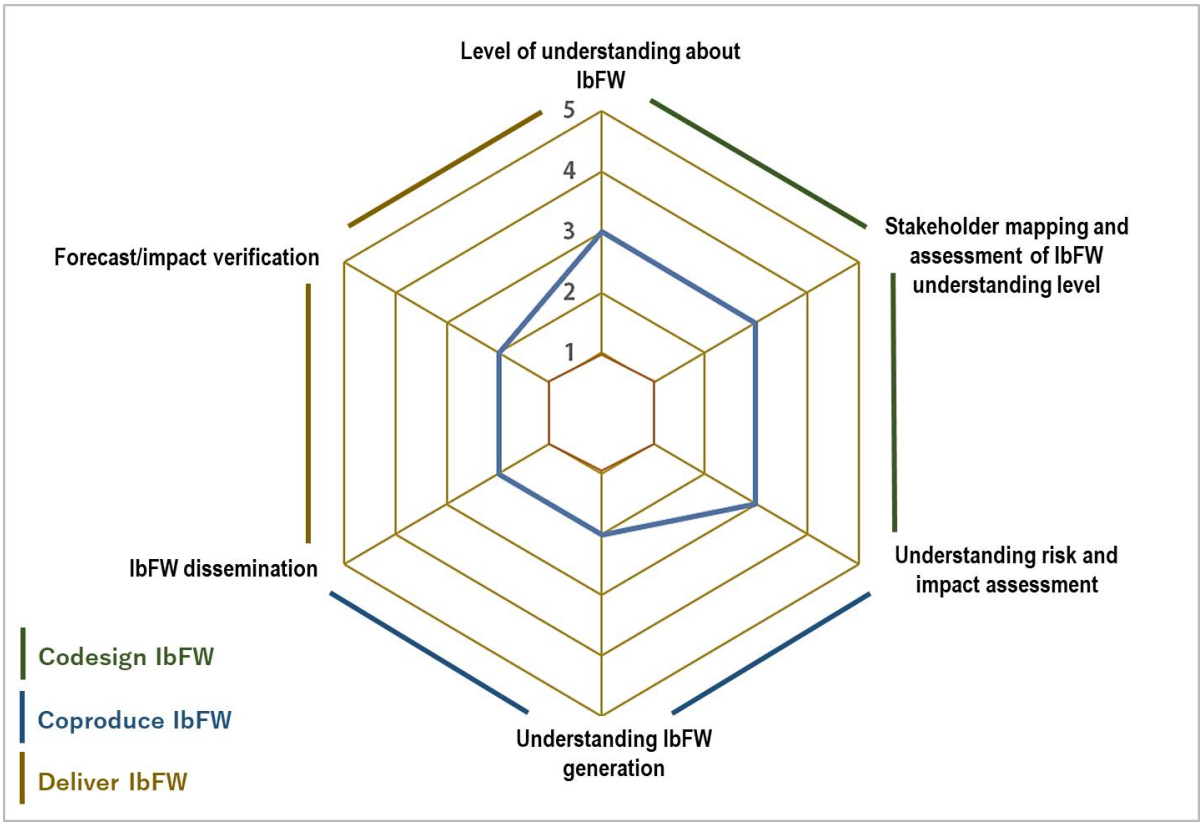

Figure (26): Overall IbFW Readiness within MAFF. (Scale: 1-Very Low (Very low understanding and capacity); 2-Low (Low understanding and capacity); 3-Medium (Medium understanding and capacity); 4-High (High understanding and capacity); 5-Very High ((Very high understanding and capacity)

3. Component-wise Assessment:

3.1. Level of Understanding about IbFW

In order to better assess the understanding about Impact-based Forecasting and Warning (IbFW) in Cambodia, line of enquires and focus of the discussion was put on definition and standard terminologies of IbFW. The understanding about key elements of IbFW were also assessed including understanding about forecast (meteorological and hydrological), hazards, exposure, vulnerability and risk. Institutions have some understanding about IbFW, especially about forecast and warning part being very clear. Which means, these institutions have good understanding about "what the weather and impending hazard will be", compare to "what the weather will do". These institutions have basic understanding about IbFW from various international and regional trainings events and workshops, which they have participated in recent the past. These institutions understand that inclusion of impact on humans, livelihoods/businesses, infrastructure and agriculture makes impact-based forecasting unique among other traditional forecasts and warnings. There is no functional IbFW at this juncture and institutions haven't produced any IbFW products in Cambodia. However, there do exist Standard Operating Procedure (SOP) for early warning system (EWS) that has been developed by UNDP in consultation with NCDM, MoWRAM, MAFF and Mekong River Commission

between May to December 2019[33].. As per mandate, two institutions of the Ministry of Water Resources and Meteorology (MoWRAM) are responsible for regular forecasting and early warning of hydro meteorological hazards. The Department of Meteorology (DOM) provides forecasts for heavy rain and flash flooding and storms. The Department of Hydrology and River Works (DHRW), is the main agency responsible for flood forecasting. Level of understanding about IbFW amongst institutions is under medium category in Cambodia **(Score of 3.0).** (**Refer to Figure (23)**)

3.2. Stakeholder Mapping and Assessment of IbFW Understanding Level

This section of IbFW readiness assessment is intended to highlight and provide an understanding of institutions about regional, national and local level stakeholders with a 'stake' in IbFW in Cambodia. There are wide range of potential stakeholders (institutions and individuals) with a 'stake' in IbFW in Cambodia. There is no functional IbFW in Cambodia at this juncture. The assessment also highlights the role of regional stakeholders (i.e. MRC, ASMC) beyond Cambodia, which nevertheless have an important influence over the forecast and warning mechanism at national and local level. A simple spatial hierarchy have been used to categories stakeholders according to their area of mandated operations and engagement such as, supra-national/Inter-Governmental (Global), regional (within ASEAN), national (within Cambodia at national level), sub-national (within Cambodia at provincial level), community level (NGO/CBO/CSO) and think-tanks or individuals. Institutions know "who-is-who" in country, however in absences of appropriate guidelines or SOP on IbFW, it was difficult for them to explain about their potential role in present context and near future. Apart from government institutions at national level, there are few regional organizations who also plays a very crucial role in dissemination of IbFW. Such as, MRC established Regional Flood and Drought Management Centre (RFDMC) to issue flood forecasts and warning information during the wet season, and drought forecasts and warning information during the dry season. The RFDMC issues flood forecasts and warning information daily during the wet season, and drought forecasts and warning information weekly during the dry season. There are few community level organizations active in Cambodia and also working closely with institutions. Understanding about stakeholder and about their mandated roles within IbFW amongst institutions is medium in Cambodia **(Score of 3.0).** (**Refer to Figure (23)**)

3.3. Risk and Impact Assessment

From the assessment, the result shows that there is a lack of understanding on cascading hazards within MoWRAM, NCDM and MAFF which could potentially be enhanced through capacity building. It is also clear from all three organizations who has mentioned flashfloods as a new hazard in Cambodia while storms, typhoon and drought are the most frequently occurring hazards in Cambodia which directly affects the agriculture sector the most followed by housing,

[33] https://www.adaptation-undp.org/Cambodia-EWS-standard-operating-procedures

livelihood, business and critical infrastructure respectively. However, none of them mentioned about landslides in Cambodia. There is a strong awareness of the impacts to vulnerable groups, especially elderly, people with disabilities, indigenous groups, and children.
Regarding to the availability of exposure and vulnerability data in Cambodia, the results show that there is a data archive only for historical monthly and annual climate data but no recorded impact information yet. Moreover, it is also clear that there is a lack of hazard maps including floods (riverine flood, urban flood and flash flood) and drought in Cambodia. On the other hand, the assessment results have suggested that MoWRAM and MAFF are not well aware of the availability of hazard maps within the country including through PRISM system developed by WFP. The capacity building on hazard assessment, impact assessment, collection of impact data, pre- and post-processing data including data management and how to relate impacts and extreme climate events are needed to enhance their existing capacities which as a result would help support IbFW development in Cambodia in the long-run.

From the overall analysis, there is a lack of understanding of risk assessment especially the definition of vulnerability including physical, environmental, social and economic vulnerability dimensions **(Score of 2.0)**. Training should be provided at the basic conceptual level to advanced level for MoWRAM and MAFF and at basic to intermediate level to NCDM as they have the mandate to assess risks for disaster risk management. (**Refer to Figure (23)**)

3.4. IbFW Generation

The most critical component of the IbFW assessment is the generation of forecast and warning information. The provision of timely impact-based forecasts allows for the deployment of response and recovery activities for saving lives and property, as well as positioning of humanitarian aid before the hazard occurs. The impacts and risk that should be addressed are varied from area to area within the country.

Department of Meteorology (DOM) of MoWRAM is the mandated agency in Cambodia to develop and issue weather and climate forecasts. Since DoM is already having a medium level capacity to produce traditional weather forecasts, there is a great potential to further improve its capacity to support IbFW. DOM has the confidence to make that change within a short period of time if they receive proper guidance and financial supports from external agencies. However, DOM requires improvement on risk and impact assessment. Most of the necessary data for risk and impact assessment can be accessed from NCDM, MAFF and other relevant agencies. Since the co-development engagement between agencies is also weak at the moment, it is most important to improve the data sharing, coordination and collaboration among the relevant agencies to produce better IbFW. There is also a good possibility for NCDM and MAFF to convert the existing traditional weather forecast which is usually received by DOM to IbFW up to certain extent by strengthening their existing capacity. Overall, the IbFW

generation component in Cambodia needs attention and capacity enhancement to meet the required IbFW standards and subcomponents **(Score of 2.0)**. (**Refer to Figure (23)**)

3.5. IbFW Dissemination

Dissemination is an integral part of any forecast and warning system. Institutions have good understanding about traditional forecast and warning, however IbFW needs specials attention on representation and visualization of forecast and warning with impact level. In Cambodia, social media platforms such as Facebook, Twitter are a very common mode of communicating forecast and warning. Apart from social media, electronic media (such as TV, Radio), SMS and print media also play a very crucial role in communicating such information. During the assessment, institutions highlighted the importance of infographics, pictures and photos in forecast and warning, instead of technical wordings. It has also highlighted the importance of the use of color schemes while disseminating IbFW. Understanding about IbFW dissemination amongst institutions is low to medium in Cambodia, however, as a way forward there is a need to look into the prospects of Common Alerting Protocol (CAP) based on the EWS1294 that is already operational **(Score of 2.0).** (**Refer to Figure (23)**)

3.6. Forecast/Impact Verification

Verification provides significant insight into the accuracy and effectiveness of IbFW and drives improvements. Without verification, forecast results cannot be considered reliable. To develop and trigger actions based on a forecast, responders must know if the forecast is providing accurate information on the likelihood of an event and its impacts.

DOM, NCDM and MAFF are currently trying to perform the verification on the forecast after each event. However, collecting, collating and archiving the required data for the verification process i.e., Historical forecasts, Historical observations and Historical data on disaster impacts are quite weak **(Score of 2.0)** whereas collecting and archiving historical meteorological observation are progressing well over the years. Through this assessment effort was made to understand the current scientific methodologies/approaches being used for verification process by these agencies. It is therefore noticed that there is no proper scientific methodology/approach in place and requires the much-needed attention on improving the capacities for verification process, evaluation, and forecast skill assessment for all three agencies in Cambodia. (**Refer to Figure (23)**).

SECTION

D

RECOMMENDATIONS

SECTION D | RECOMMENDATIONS

D.1 | Cambodia

1.1. Level of Understanding about IbFW

- Based on the assessment outcomes, it is found that Cambodia lacks functional IbFW and institutions does not produce any IbFW products.
- Therefore, it is recommended that Cambodia updates and enhance the dissemination of existing Standard Operating Procedure (SOP) on early warning system so that IbFW can be appropriately deployed in the long-run.
- Strengthening the capacity of mandated agencies through training and specialized courses would help broaden their knowledge and skills to implement IbFW in Cambodia.

1.2. Stakeholder Mapping and Assessment of IbFW Understanding Level

- In terms of stakeholder engagements, institutions in Cambodia are aware about "who-is-who" in the country, but due to the absence of appropriate guidelines or SOPs on IbFW, there is always a lack of understanding about the potential role of the stakeholders and their level of engagements within the Government entities.
- Therefore, it is recommended that guidelines are developed, standard terms of references (ToRs) for stakeholders are identified according to the level of engagements with the Government.

1.3. Risk and Impact Assessment

- The assessments results have shown that understanding on cascading hazards within MoWRAM, NCDM and MAFF is considerably weak and specialized courses or training programmes need to be introduced to build institutional capacities.
- Considering the very limited knowledge on risk and vulnerability assessments, it is recommended that training and capacity building programmes on risk, exposure and vulnerability assessments be provided to the targeted institutions so that their knowledge and skills are enhanced and they are able to use this information for decision-making and planning purposes.
- Pre- and post-processing data including data collection, processing, management and relating it to impacts and extreme climate events are needed to enhance their existing capacities that would strongly support development of IbFW in Cambodia.
- It is also recommended that training should focus on basic conceptual to advanced level.

Section D: Recommendation

1.4. IbFW Generation

- In order to maintain data consistencies, it is recommended that data sharing mechanisms such as agreements between agencies and archiving through a common data platform be put in place for proper inter-agency coordination on data management and access so that inconsistencies in data collected by different agencies can be properly standardized and used by all agencies for planning and analysis purposes. This would enhance the agencies capacities to produce better IbFW in the future.
- It is also recommended that training focusing on IbFW generation based on internationally accepted IbFW standards and guidelines be appropriately introduced.

1.5. IbFW Dissemination

- Cambodia has been using different medium on forecast and warning information dissemination. However, technical knowledge about IbFW dissemination amongst institutions is limited and requires institutions to build their capacity to strengthen their technical know-how to disseminate IbFW information. This should be done in a simple, correct and understandable language, as appropriate for the general public to ensure trust in such information whenever it is issued. With EWS 1294 already been operational in Cambodia, the prospects of adopting Common Alerting Protocol (CAP) could be a way forward to improve the early warning dissemination process.

1.6. Forecast/Impact Verification

- The assessment results in Cambodia has shown that collecting, collating and archiving the required data for the verification process that includes historical forecasts, historical observations and historical data on disaster impacts are lacking. Therefore, it is recommended that the inter-agency coordination is enhanced while data sharing agreements are made available to the institutions for access to such data and information. Therefore, it can be recommended that technical working groups be establish to ensure effective coordination.
- The assessment also highlighted the need for introducing updated scientific methodologies/approaches being used in the verification process of IbFW by these institutions. It is therefore, recommended that capacities of institutions are improved for verification process, evaluation and forecast skill assessment in Cambodia.

D.2 | Overall Recommendation for Cambodia

- Capacity building is a key to enhance the skills and knowledge on IbFW in Cambodia;
- Develop guidelines on IbFW before establishing a full-fledged IbFW system;
- Set up integrated IbFW portal (model);
- Establish inter-agency coordination mechanism;

Section D: Recommendation

- Establish data sharing agreements between agencies;
- Identify the overlapping roles between the agencies to maintain data consistencies and reliable flow of information;
- Arrange specialized courses so that knowledge and skills of staff engaged in forecasting and warning is enhanced;
- Organize training at least from basic to intermediate level to the institutions so that staff understands the methods and approaches of IbFW and apply it appropriately;
- Provide funding support not only through donor funds but also bringing in CSR funding to procure required resources to support IbFW.

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ANNEX

1

READINESS ASSESSMENT MATRIX

Annex 1: Readiness Assessment Matrix

ANNEX 1.1 | Readiness Assessment Matrix

SECTION - I: Assessment of the understanding about IBFW

1. What is Impact-based Forecasting and warning (IBFW)?	
2. How is it different from traditional weather forecast and warning?	
3. Why is it Impact-based Forecasting (IBFW) important?	

SECTION - II: Stakeholders mapping and Assessment of IBFW understanding level?

4. Have you identified and mapped stakeholders for Impact-based Forecast and Warning (IBFW) chain (national to local)? ☐ Yes ☐ No	
5. Can you provide the names of these identified IBFW stakeholders? ☐ Yes ☐ No. If yes, please provide the names of these stakeholders.	☐ MoWRAM ☐ MAFF ☐ NCDM ☐ UNDP ☐ WFP ☐ PIN ☐ GIZ ☐ Other
6. Can you categorize these identified stakeholders in to the following categories? Please follow the listed users order.	☐ disaster risk knowledge ☐ detection, monitoring and forecasting of the hazards and possible consequences ☐ warning dissemination and communication ☐ preparedness and response capability ☐ governance
7. Can you rate the level of understanding about IBFW amongst identified stakeholders? (Scale of 1 – 5)	☐ 1: very low ☐ 2: low ☐ 3: medium ☐ 4: high ☐ 5: very high
8. What is your working and information sharing mechanism with these identified stakeholders	☐ Partnerships ☐ Collaborations

Annex 1: Readiness Assessment Matrix

SECTION - III: Understanding Forecast and Warnings

9. What are the key natural hazards in your country?	☐ Flood ☐ Storm ☐ Drought ☐ Lightening ☐ Other
10. For which hazards forecast and warning information are currently being generated and issued?	☐ Flood ☐ Storm ☐ Drought ☐ Lightening ☐ Other
11. What is frequency of the forecast and warning information are currently being issued?	☐ Hourly ☐ Daily ☐ Weekly ☐ Dekadal (15-20 days) ☐ Monthly ☐ Seasonally ☐ Other
12. How forecast and warning information are currently being used in decision making and practices?	
13. What are key challenges do stakeholders face while using the existing the forecast and warning information?	
14. Have you conducted any hazard, exposure, vulnerability and risk assessment?	
15. Is there any impact information added in the existing the forecast and warning information?	
16. How can be existing forecasts and warnings information can be improvised which can provide appropriate information to enable informed decision-making and trigger action?	
17. How long will it take to embedded impact information in existing forecast and warning and produce and disseminate the impact-based forecast or warning?	☐ Short Term (1-6 months) ☐ Medium Term (6-12 months ☐ Long Term (more than a year ☐ Other

Annex 1: Readiness Assessment Matrix

18. At what spatial or administrative scale do stakeholders need forecast and warning information in order to act effectively?	☐ National ☐ Provincial ☐ District ☐ Commune ☐ Village
19. How much time will it take for stakeholders to process the information and prepare for early actions?	☐ 1-6 hours ☐ 6-12 hours ☐ 12-24 hours ☐ More than 24 hours ☐ Others

SECTION - IV: Understanding Risk and Impact Assessment

20. What is the existing mechanism of lifting the warning?	
21.1. What are the 'Cascading Hazards' and 'Expected primary and secondary impacts' of Heavy Rainfall?	☐ primary impacts ☐ secondary impacts
21.2. What are the 'Cascading Hazards' and 'Expected primary and secondary impacts' of Low Rainfall?	☐ primary impacts ☐ secondary impacts
21.3. What are the 'Cascading Hazards' and 'Expected primary and secondary impacts' of High Temperature?	☐ primary impacts ☐ secondary impacts
21.4. What are the 'Cascading Hazards' and 'Expected primary and secondary impacts' of Low Temperature?	☐ primary impacts ☐ secondary impacts
21.5. What are the 'Cascading Hazards' and 'Expected primary and secondary impacts' of High Wind?	☐ primary impacts ☐ secondary impacts
21.6. What are the 'Cascading Hazards' and 'Expected primary and secondary impacts' of Storm Surge?	☐ primary impacts ☐ secondary impacts
21.7. What are the 'Cascading Hazards' and 'Expected primary and secondary impacts' of Lightning?	☐ primary impacts ☐ secondary impacts
21.8. What are the 'Cascading Hazards' and 'Expected primary and secondary impacts' of Fog?	☐ primary impacts ☐ secondary impacts

Annex 1: Readiness Assessment Matrix

22. Which hazard have maximum impacts on housing, livelihoods, business, critical infrastructure, etc.?	☐ Flash flood ☐ Storm/Typhon/Cyclone ☐ Drought ☐ Land slide ☐ Others
23. Which group of society affected the most?	☐ ID poor 1 & 2 ☐ Vulnerable people ☐ Indigenous people ☐ Elderly ☐ Handicapped ☐ Children ☐ Others
24. Which hazard and impacts are the most complicated and difficult to deal with?	☐ Flash flood ☐ Storm/Typhon/Cyclone ☐ Drought ☐ Land slide ☐ Others
25. What are the key sectors affected by the most due to these impacts (Agriculture, Water, Transport, Health, Tourism, Energy, etc.)?	☐ Agriculture ☐ Water ☐ Transportation ☐ Health ☐ Tourism ☐ Energy (Electricity cut off) ☐ Others
26. Have you archived the historical climate data and impact records?	☐ Yes ☐ No
27. What is the duration for the historical climate data and impact records are archived?	☐ Monthly ☐ Quarterly ☐ Semester ☐ Annually ☐ Others
28. What is the quality of the historical climate data and impact records?	☐ Accuracy ☐ Good quality ☐ Frequency updating ☐ Up to date
29.1. What was (a) the frequency (b) the magnitude (related to return period) and (c) geographic distribution of impacts of the DROUGHT hazard?	

Annex 1: Readiness Assessment Matrix

29.2. What was (a) the frequency (b) the magnitude (related to return period) and (c) geographic distribution of impacts of the FLOOD hazard?	
30. What are the key vulnerabilities?	
31. What are the vulnerability indicators that are related to the identified hazards and impacts?	
32. What are the key elements of exposures?	
33. What is the quality and availability of data for vulnerability and exposure assessments?	
34. Have you Identified impact levels from hazard thresholds? If yes, what are the hazards that thresholds have developed?	
35.1 Is there any future climate change projections data are available at national and local scale?	
35.2. If yes, provide some details of available GCMs, scenarios, time periods and resolution of data.	

SECTION - V: Understanding IBF and Warning Generation

36. Have you conducted any impact assessment using those climate change projections? if yes, Name those studies?	
37.1. How many staff are engaging in the process of IBF development and dissemination?	
37.2. What are the expertise areas of staff engaging in the process of IBF development and dissemination?	
38. Is this number of staff sufficient for catering the demand? if not, how many staff are you expecting?	

Annex 1: Readiness Assessment Matrix

39. What are the tools/software do you use to produce Impact-based forecast and warning?	
40. Which existing forecasts and warnings can be adapted to meet the user requirements of impact-based forecast services?	
41. Select the content of existing impact-based forecasts and warnings	
42. What capabilities are needed to produce the impact-based forecasts and warnings that will meet the user requirements?	

SECTION - VI: Partnerships and collaboration

43. Do you have any current pilot project that IBF is testing? If yes, what projects?	
44.1. Have you identified potential partners and collaborators who should be engaged with in developing IBFs?	
44.2. Who are they?	
45. What support are you expecting from them?	

SECTION - VII: IBF Dissemination

46. Which language(s) preferred by the stakeholders in your country for forecasts and warnings?	☐ Simple ☐ Laymen ☐ Technical/Mix
47. How do stakeholders access forecasts and warnings?	
48. How should the information be presented?	☐ What visuals, ☐ What word choices, and ☐ What color schemes?
49. Which mode stakeholders preferred for the forecasts and warnings?	☐ Television ☐ Social Media ☐ Newspaper ☐ SMS

Annex 1: Readiness Assessment Matrix

50. How impact levels can be communicated to support decision-making and action?	
51. What is the IBF dissemination flow in your country? (Hint: Draw a flow diagram of institutes/people in a separate paper)	
52. Are there any known issues and challenges in the dissemination flow? If yes, what are those?	
53.1 Are you receiving any feedback from stakeholders who are involved in this dissemination flow? If yes, what are those feedbacks?	
53.2 Are you documenting these feedbacks for future references?	
54. Did you have any business continuity plans and measures during any failures of normal dissemination channels?	

SECTION - VIII: Forecast/Impact Verification

55.1. Are you usually performing a forecast/impact verification?	
55.2. How frequent do you usually perform the verification?	☐ After each event ☐ Seasonally ☐ Annually
56. Are you regularly collection, collating and archiving following data?	☐ Historical forecasts ☐ Historical observations ☐ Historical data on disaster impacts
57. What kind of benefit do you get from verification process to improve the IBF?	
58. What are the key challenges you are facing when producing impact-based forecasting?	

Annex 1: Readiness Assessment Matrix

ANNEX 1.2 | Readiness Assessment in Cambodia (Responses)

Assessment of Understanding about IbFW

In order to assess the understanding of impact-based forecasting of the targeted institutions, three specific definitions have been posed to the institutes as given in **Table (1).**

Table (1) represents the accepted definitions of IbF

Sr. No.	IbF Definitions	Institutions		
		MoWRAM	NDMO	MAF
1.	Impact-based forecasting drives actions which save lives and protect property and livelihoods	√	√	√
2.	Impact-based forecasting provides information on the level of risk a hazard poses to a specific area	√	√	√
3.	Impact-based forecasts and warnings provide an assessment of the forecast weather or climate hazard and an assessment of the possible impacts, including when, where and how likely the impacts are	√	√	√

Perception about Impact-Based Forecasting and Warning (IBFW) compare to traditional weather forecasting in Cambodia

According to the targeted surveyed institutions perspective, the following responses have been received:

Department of Meteorology (DOM) Perspective

1. Traditional weather forecast follows the existing mechanisms through the use of local knowledge and information on weather and climate and lacks technological advancements to provide timely and accurate information.

National Committee for Disaster Management (NCDM) Perspective

1. Traditional weather forecasts is based on local knowledge and information while IBFW is more advanced providing precise and accurate information.
2. The difference between traditional weather forecasting and impact-based weather forecasting and warning (IBFW) is that IBFW used scientific model and data to predict likely consequences and impacts of hazard/disaster while traditional forecast model uses indigenous knowledge and low-tech tools. In addition, the traditional model only forecast the occurrence of the hazard, while IBFW looks beyond up to the impact level of the event

Annex 1: Readiness Assessment Matrix

Ministry of Agriculture, Forestry and Fisheries (MAFF) Perspective

1. IBFW uses scientific model and data to predict likely consequences and impacts of hazard/disaster while traditional forecast model uses indigenous knowledge and traditional tools that focus on the occurrence of the hazard.

Importance of Impact-based Forecasting and Warning (IbFW)

Table (2) shows the importance of IbF

DOM	NCDM	MAFF
Reduces the impact of damaged and loss through early warning and long-term forecast.	Reduces the impact of damaged and losses through early warning and long-term forecasts and also considering other hazards with both positive and negative impacts.	Because IBFW can be used to reduce the impact of damage and loss through early warning and long term forecast and other hazards both positive and negative.
	IBFW is critically important because it offers forecast information and warning of pre-hazard event related to the occurrence of hazard and more importantly the likely impact which this can help to formulate specific decision and take appropriate measures on preparedness for timely response to save lives and reduce economic loss. In more specific term, IBFW can help stakeholders to timely adopt anticipatory action for emergency response and recovery.	

Stakeholder Mapping

Stakeholders Mapping and Identification for IBFW from National to Local Levels

DOM, NCDM and MAFF has responded that stakeholders have been identified and mapped in Cambodia.

Annex 1: Readiness Assessment Matrix

Table (3) represents the stakeholder mapping in Cambodia.

Agency Name	Stakeholders	
	Government	International
DOM	MoWRAM, MAFF, NCDM	UNDP
NCDM	MoWRAM, MAFF, NCDM	UNDP, WFP, PIN
MAFF	MoWRAM, MAFF, NCDM	UNDP, WFP

Level of Understanding about IBFW amongst Stakeholders

Based on the assessment results, when asked to rate the level of understanding and knowledge about IBFW of different stakeholders, all three agencies, DMH, NDMO and MAF have put the score at 3 meaning medium level understanding. **Figure (1)** represents level of understanding about IBFW amongst stakeholders.

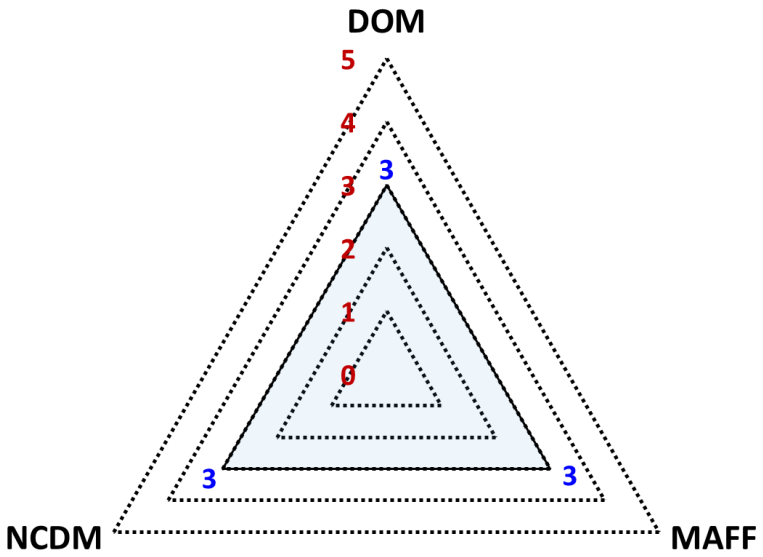

Figure (1): Radar chart showing the level of understanding and knowledge about IBFW of different stakeholders through the scores provided by DOM, NCDM and MAFF. (Scale: 1-Very Low; 2-Low; 3-Medium; 4-High and 5-Very High)

Working Relationships with the Stakeholders

In terms of working relationships with the different stakeholders, all three agencies have identified the relationships as follows.

Annex 1: Readiness Assessment Matrix

Table (4) represents working relationships amongst stakeholders in Cambodia.

Sr. No.	Stakeholder Relationships	Institutions		
		DOM	NCDM	MAFF
1	Government Mandate	√	X	X
2	Memorandum of Understanding (MoU)	X	X	X
3	Project-based Partnerships and Collaborations	√	√	√
4	Contracts	X	X	X
5	Others	X	X	X

Understanding Forecast and Warnings

List of Key Natural Hazards in Cambodia

Stakeholders identified prominent hazards in Cambodia based on historical events. These hazards are floods, droughts, storms and lightening are the key hazards identified by all three agencies.

Table (5) represents key natural hazard in Cambodia.

Sr. No.	Key Hazards	Institutions		
		DOM	NCDM	MAFF
1	Floods	√	√	√
2	Droughts	√	√	√
3	Storms	√	√	√
4	Lightening	√	√	√

Hazards Forecast and Warning Information that are Currently being Generated and Issued

All the three agencies that is Department of Meteorology (DOM), the National Committee for Disaster Management (NCDM) and Ministry of Agriculture, Forestry and Fisheries (MAFF) have responded by saying that the current hazard forecast and warning information are being issued only for the key hazards identified above and the information are available on daily and weekly basis.

Annex 1: Readiness Assessment Matrix

Frequency of Forecast and Warning Information Issued

Table (6) represents frequency of forecast and warning information issued by various agencies in Cambodia. Cambodia generates daily, weekly and seasonal products.

Agency	Frequency of Forecast and Warning Information Issued					
	Hourly	Daily	Weekly	Dekadal	Monthly	Seasonal
DOM	X	√	√	X	X	X
NCDM	X	√	√	X	X	√
MAFF	X	√	√	X	X	√

Forecast and Warning Information Presently being used for Decision-Making

Department of Meteorology (DOM)

- Forecast and warning information are being used for long-term planning purposes.

National Committee for Disaster Management (NCDM)

- NCDM receives the forecast and warning information from DOM which is then used for preparedness and response purposes.

Ministry of Agriculture, Forestry and Fisheries (MAFF)

- Forecast and warning information are used for planning the development of Agriculture Sector Development Plan (ASDP) and Preparation of Agricultural Development Plan (PADP).

Key Challenges Stakeholders Face while using Forecast and Warning Information

Department of Meteorology (DOM)

- Stakeholders have limited knowledge on the understanding of existing forecast and warning information in response to the occurrence of hazards.

National Committee for Disaster Management (NCDM)

- The key challenges are the limited knowledge of stakeholders in understanding the existing forecast and warning information in response to the hazard's occurrence;
- Limited understanding of the required actions on preparedness at local level/end user level after the warning or forecast is issued.

Ministry of Agriculture, Forestry and Fisheries (MAFF)

- Knowledge limitation is the biggest challenge.

Annex 1: Readiness Assessment Matrix

Hazard, Exposure, Vulnerability and Risk Assessment

Table (7) represents knowledge about Hazard, Exposure, Vulnerability and Risk Assessment in Cambodia.

Agency Name	Hazard, Exposure, Vulnerability and Risk Assessment
DOM	No risk assessment is done in Cambodia
NCDM	No systematic assessment was done at the national level or at national scale, but there has been some small-scale assessment conducted with some development partners.
MAFF	No national level risk assessment was done in Cambodia, only pilot scale assessments were done with development partners.

With regards to any impact information added in the existing forecast and warning information, NCDM has mentioned that only Platform for Real-time Impact and Situation Monitoring (PRISM) to some extent is complimenting this information as it indicates the likely impacts. However, PRISM lacks forecast component.

Need for Improving the Existing Forecasts and Warning Information for Informed Decision-Making and Triggering Action

Department of Meteorology (DOM)

- Introduce new methods and approaches to improve the forecast and warning information for better actions.

National Committee for Disaster Management (NCDM)

- At a moment, the forecast and warning are provided to help in the decision-making process;
- However, there is need to improve the existing forecast and warning model to cover climate change aspect given that climate change implication and impact is being felt in the country.

Ministry of Agriculture, Forestry and Fisheries (MAFF)

- The weather forecast is available to support decision and planning at national and sub-national level.

Annex 1: Readiness Assessment Matrix

Table (8) Time Needed to Embed Impact Information in Existing Forecast and Warning to Produce and Disseminate IbFW

Sr. No.	Period (months)	Institutions		
		DOM	NCDM	MAFF
1	Short-term (1-6 months)	√	X	X
2	Medium-term (6-12 months)	X	X	X
3	Long-term (more than a year)	X	√	√

Table (9) Administrative Scale at which Impact-Based Forecasting and Warning (IBFW) is Needed

Sr. No.	Administrative Level	Institutions		
		DOM	NCDM	MAFF
1	National	√	√	√
2	Provincial	√	√	√
3	District	√	√	√
4	Village/Commune	√	X	X
5	Municipalities	X	X	X

Table (10) Time Taken by Stakeholders to Process Information and Prepare Early Actions

Sr. No.	Time for Early Action	Institutions		
		DMH	NDMO	MAF
1	1-6 hours	X	X	X
2	6-12 hours	X	X	X
3	12-24 hours	√	√	√
4	> 24 hours	X	X	X

Existing Mechanisms to Lift Warning

According to DOM, MoWRAM have mechanisms in place for weather forecast and warning before the occurrence of the hazard and share that information with NCDM for planning and response. Based on the disaster situation, MoWRAM sends out notification to lift the warnings. NCDM receives the warning information from MoWRAM and shares it with the Provincial Committee for Disaster Management (PCDM), District Committee for Disaster Management (DCDM) and Commune Committee for Disaster Management (CCDM) which is then relayed it to the public. For MAFF, they do not receive direct information from MoWRAM at present but MoWRAM is now developing a mechanism where information shared to the public will also be made available in MAFF website and their social media for greater awareness.

Annex 1: Readiness Assessment Matrix

Understanding Risk and Impact Assessment

Cascading Hazards due to Weather Conditions and its Impacts

While the question on cascading hazards impacts was asked to all three agencies (DOM, NCDM and MAFF) based on the following criteria's like heavy rainfall, low rainfall, high temperature, low temperature, strong winds, storm surge, lightening and fog, all the targeted agencies have only identified the cascading hazard impacts as primary impacts and secondary impacts with giving further elaborations.

Table (11) Cascading Hazards and its Impacts

WC	Agencies		
	DOM	**NCDM**	**MAFF**
Heavy Rainfall	PI	PI/SI	PI
Low Rainfall	SI	SI	PI
High Temperature	SI	PI/SI	PI
Low Temperature	SI	SI	PI
Strong Winds	PI	PI/SI	PI
Storm Surge	PI	PI/SI	PI
Lightening	PI	PI	PI
Fog	SI	SI	PI

Abbreviations: Weather Conditions (WC); Primary Impacts (PI); Secondary Impacts (SI)

Hazards and its Impacts

In terms of maximum hazard impacts on housing, livelihood, business, critical infrastructure, etc., all three agencies have identified floods (specifically flash floods), droughts, tropical storms/cyclones and Typhoons to have direct impacts. All three agencies have identified that the most affected groups of society include, the vulnerable communities, elderly people, disabled people, pregnant women and ID Poor (Category 1 and 2)[34]. All three agencies have also identified the following hazards that they found it difficult and complicated to handle and that includes flash floods, droughts, tropical storms/cyclones and typhoons. In terms of the direct effects on key sectors, agriculture, energy, water, transport, tourism, health and electricity are found to be directly impacted by hazards.

[34] IDPoor: A Poverty Identification Programme that Enables Collaboration Across Sectors for Maternal and Child Health in Cambodia (doi: https://doi.org/10.1136/bmj.k4698)

Annex 1: Readiness Assessment Matrix

Climate Data Archive and its Availability

All three agencies appear to have maintain climate data archives for their work. However, the agencies have not been able to provide the duration for which the climate data records are available.

Table (12) Climate Data Availability

Sr. No.	Climate Data Archive	Institutions		
		DOM	NCDM	MAFF
1	Historical Climate Data Records Maintained	√	√	√
2	Does not Maintain Historical Climate Data Records	X	X	X

Climate Data Quality

In terms of climate data quality, all three agencies (DOM/NCDM/MAFF) has put the quality score between 3-4 meaning 'medium' to 'high' quality when asked to measure in the scale of 1-5. DOM has given the score of 4 (high) while NCDM and MAFF has given the score of 3 (medium). Average score from all three agencies is 3.3 (medium) **Figure (2)**.

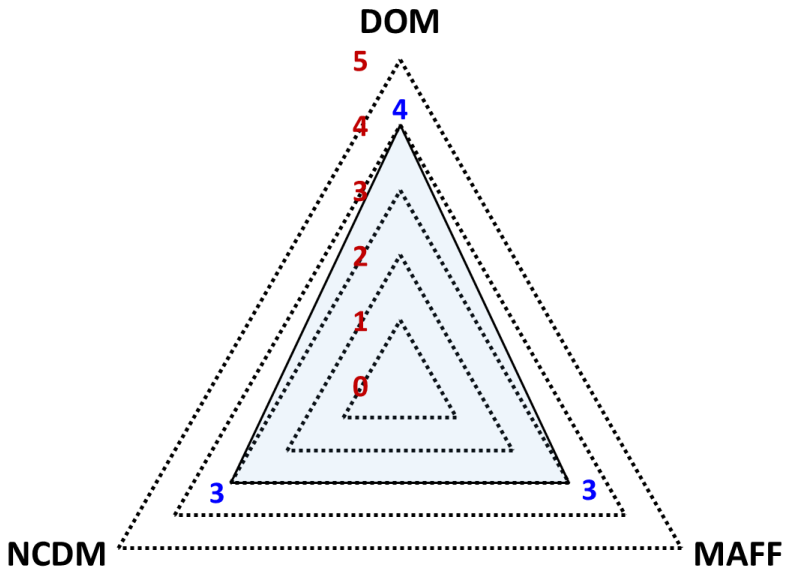

Figure (2): Radar chart informing about climate data quality through the scores provided by DOM, NCDM and MAFF. (Scale: 1-Very Low; 2-Low; 3-Medium; 4-High and 5-Very High)

Annex 1: Readiness Assessment Matrix

Impacts of Specific Hazards in terms of Frequency, Magnitude and Geography

Table (13) Drought Frequency, Magnitude and Geography

Sr. No.	Drought Hazard			
	Agencies	Frequency	Magnitude (return period)	Geography
1	DOM	Every 1-2 years	Not aware	Whole country
2	NCDM	Every 1-2 years	Not aware	Whole country
3	MAFF	Not aware	Not aware	Whole country

Table (14) Flood Frequency, Magnitude and Geography

Sr. No.	Flood Hazard				
	Agencies	Frequency	Magnitude (return period)	Geography	Remarks
1	DOM	Every year	Not aware	Not specific	-
2	NCDM	Almost every year	Not aware	Not specific	General observation is that in the last 3 years (2019, 2020, 2021); there is annual flash flood almost every year. This is a new trend, and this could be due to the impact of climate change.
3	MAFF	Not aware	Not aware	Not specific	

Key Challenges Identified based on the Key Hazards

Department of Meteorology (DOM)

- Houses made from low-quality materials vulnerable to damage.
- Impact on infrastructures and economic livelihood activities is severe.

National Committee for Disaster Management (NCDM)

- Houses made from low-quality materials are highly vulnerable to damage. However, more indirect vulnerabilities such as poverty and illiteracy also play a role in individual's ability to prepare for and cope with the impact.
- More indirect vulnerabilities such as poverty, gender issue, diversity, societal power relation, natural resource degradation and literacy also play a role in individual's ability to prepare for and cope with the impact.

Annex 1: Readiness Assessment Matrix

Ministry of Agriculture, Forestry and Fisheries (MAFF)

- Some vulnerabilities such as poverty, gender issue, diversity, social relation, natural resources degradation and literacy poses challenges on an individual's ability to prepare for and cope with the impact.

Quality and Availability of Data for Vulnerability and Exposure Assessments

In terms of data quality for vulnerability and exposure assessment, all three agencies (DOM/NCDM/MAFF) has put the quality score between 1-2 meaning 'very low' to 'low' quality when asked to measure in the scale of 1-5. DOM and NCDM has given the score of 2 (low) while MAFF has given the score of 1 (very low). Average score from all three agencies is 1.7 (Very Low) **Figure (3)**.

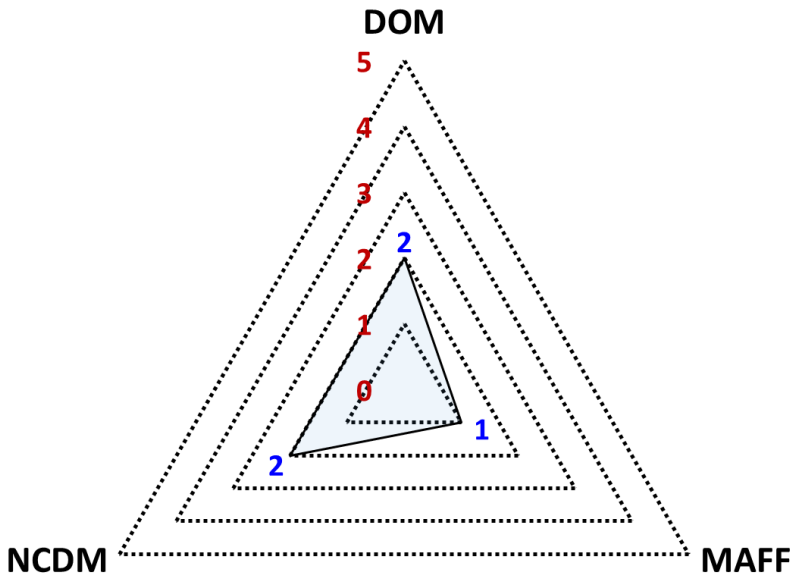

Figure (3): Radar chart showing the quality of data available for risk assessment through the scores provided by DMH, NDMO and MAF. (Scale: 1-Very Low; 2-Low; 3-Medium; 4-High and 5-Very High)

Hazards for which Threshold Levels Have Been Developed

All three agencies have mentioned that they are not aware of any hazard thresholds for Cambodia and is also unaware of any risk assessment work being carried out for the whole country.

Annex 1: Readiness Assessment Matrix

Availability of Future Climate Projections Data from National to Local Levels

Table (15) Data on Future Climate Scenarios

Sr. No.	Future Climate Scenario Data				
	Agencies	Yes	No	Response	Impact Assessment using Climate Projections
1	DMH		√	Not available	None
2	NDMO		√	Not available	None
3	MAF		√	Not available	None

Understanding IBFW Generation

Staff Engagement for IbF Development and Dissemination

Table (16) Staff Engagements

Sr. No.	Staff Engagement for IBF Development and Dissemination			
	Agencies	Staff (Number)	Expertise	Staff Sufficiency
1	DOM	Not aware	Some staffs may have expertise to engage in the IBFW development and dissemination	Do not have sufficient staff and majority of them are not specialized in meteorology
2	NCDM	Not aware	Many staffs have attended emergency assessment training for both emergency and post-disaster need assessment (PDNA), so with this knowledge they may have some foundational knowledge to support the IBF development	It is not mandatory for NCDM to have specialized persons on IBFW as such information are shared from MoWRAM but NCDM's need is to enhance staff capacity to understand IBFW to help in preparedness and response activities
3	MAFF	Not aware	Not aware	Not applicable

Current use of Tools/Platforms for Impact-Based Forecasting and Warning (IBFW)

Tools/Data being used by DOM

- Weather station, Weather Radar, Satellite data, and modern forecast methods.

Annex 1: Readiness Assessment Matrix

Tools/Data being used by NCDM

- Not aware of any software needed for IBFW as it is a technical issue, however MoWRAM has its Weather station, Weather Radar, Satellite data, and modern forecast and the information generated by MoWRAM are shared with NCDM from time-to-time.

Tools/Data being used by MAFF

- Use social media

Existing Forecasts and Warnings to be Adapted to Meet User Requirements of IbF Services

DOM and NCDM are not aware of the equipment/tools required for monitoring, analysis, forecasting and warning information dissemination as both agencies do not have any capacity on IBFW. However, **MAFF** considers social media could be a good platform for meeting user requirements since everyone has access to Facebook, Twitter, WhatsApp, etc.

Content of Existing Impact-Based Forecasts and Warnings

All the three agencies have been asked to identify the contents related to IBFW which have already been included in their existing forecast and warning based on the given six criteria's:

i. Time and date of expected impacts
ii. Location of impacts
iii. Severity and likelihood of impacts
iv. Types of impact
v. Hazard information
vi. Advice and guidance on what actions to take

The result suggests that only DOM have included the criteria's from (i) to (vi) appropriately. Both NCDM and MAFF are not aware of the criterions. **Figure (4)** represents various content in existing IbFW.

Annex 1: Readiness Assessment Matrix

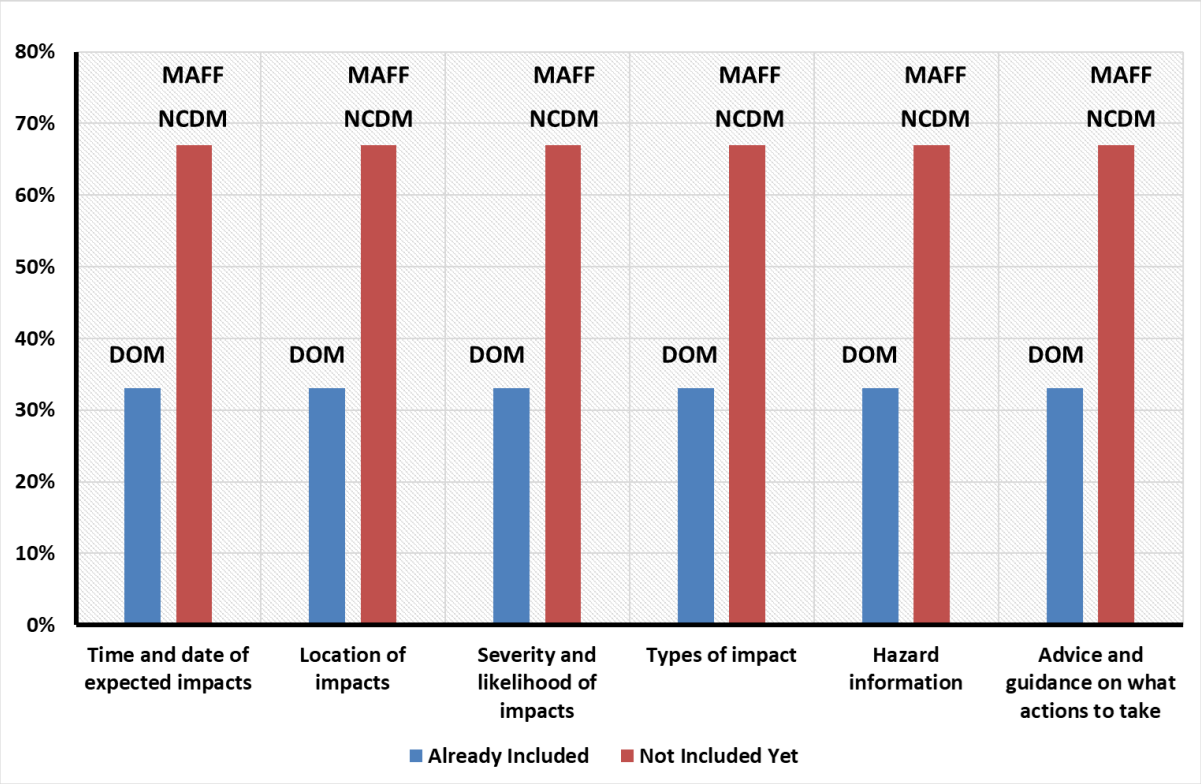

Figure (4) represents various content in existing IbFW

Capabilities needed to produce IbFW to Meet User Requirements

- DOM will require additional tools related to IBFW, together with capacity building in areas of meteorology, disaster management, remote sensing and Information Technology.
- NCDM will require capacity building on IBFW on understanding how IBFW information can be used for preparedness and response.
- MAFF considers it to be not applicable.

Current Pilot Project where IBF is being Tested

Table (17) Information on IBF Pilot Projects in Cambodia

Sr. No.	Agency	Yes	No
1	DOM		√
2	NCDM		√
3	MAFF		√

Annex 1: Readiness Assessment Matrix

Partnership and Collaboration

Identified Potential Partners and Collaborators to be Engaged in Developing IbFs

Table (18) Potential Partners in Cambodia

Sr. No.	Agency	Yes	No	Potential Partners
1	DOM	√		WMO, Japan, Korea, and ASEAN
2	NCDM	√		WMO, Japan, Korea, and ASEAN
3	MAFF		√	None

Expectations from Partner Agencies

- DOM: Knowledge sharing, transfer of technology and capacity building.
- NCDM: Need of advance technology, financial and material resources, knowledge and capacity building.
- MAFF: Not applicable.

IbFW Dissemination

Language(s) Preferred by Stakeholders for Forecasts and Warnings

Table (19) Language of information dissemination

Sr. No.	Agency	Simple/laymen	Technical	Mix (Simple & Technical)
1	DOM	Not applicable	Not applicable	√
2	NCDM	√	√	√
3	MAFF	Not applicable	Not needed for Public	√

Access to Forecast and Warnings for Stakeholders

Use of social media such as Facebook, Twitter, etc. being one medium while telegram, television and SMS could also be another medium that can be used.

Presentation of Information to Stakeholders and the General Public

All three agencies have been asked about the presentation of information that is to be disseminated to the public based on visuals, color schemes and word choices. All of them responded that (a) visuals should include infographics, pictures and photos, (b) word choices should be simple and understandable and (c) color schemes should be based on standard guidelines defined by WMO or by the national agencies in the country.

Communicating Impact Levels to Support Decision-Making

- DOM: DOM suggest that there should be primary level of interventions.

Annex 1: Readiness Assessment Matrix

- NCDM: For NCDM too primary level of interventions is needed. Information should be communicated to both technical team and leadership/management in the organization in order to encourage for timely decision-making and actions.
- MAFF: Information should be communicated to both technical team and leadership/management in the organization to encourage timely decision-making and actions.

In terms of receiving feedbacks from stakeholders engaged in dissemination flow, the major feedback has been the accuracy of information shared with stakeholders. Generally, the feedbacks received are also documented by both DOM and NCDM, however, MAFF does not document such feedbacks. With regards to Business Continuity Plans (BCPs), all three agencies have mentioned that there are no written BCPs available at present.

Forecast/Impact Verification

Table (20) Forecast/Impact Verification

Sr. No.	Agency	Yes	No	Frequency of Verification
1	DOM	√		After each event
2	NCDM	√		After each event and Seasonally
3	MAFF		√	Not applicable

Table (21) Collecting, Collating and Archiving Data

Sr. No.	Agency	Historical Forecasts	Historical Observations	Historical Data on Disaster Impacts
1	DOM	√	√	Not applicable
2	NCDM	√	√	√
3	MAFF	X	X	X

Table (22) Benefits from Verification Process to Improve IbF

Sr. No.	Agency	Benefits from Verification Process
1	DOM	Help improve the accuracy of information dissemination and warning
2	NCDM	• Help improve the accuracy of information dissemination and warning • Improve the verification and accuracy of information dissemination, thereby allowing accurate and timely planning for action.
3	MAFF	• Not applicable

Annex 1: Readiness Assessment Matrix

Key Challenges Faced while Producing Impact-based Forecasting

- Human resources are limited;
- Limited institutional capacity;
- Lack of financial support.

Annex 2: Meetings with Agencies

ANNEX

2

MEETINGS WITH THE AGENCIES

Annex 2: Meetings with Agencies

ANNEX 2 | List of Agency Contacts with whom the Survey Has been Conducted

List of Stakeholders Surveyed in Cambodia		
Date	**Agency**	**Representative Expert/Specialist**
30 November 2021	National Committee for Disaster Management	Project briefing meeting attended by NCDM officials and staff
04 January 2022	Department of Meteorology, Ministry of Water Resources and Meteorology (MoWRAM), Royal Government of the Kingdom of Cambodia	Mr. OUM Ryna, Director of Department of Meteorology
11-13 January 2022	National Committee for Disaster Management (NCDM), Royal Government of the Kingdom of Cambodia	H.E Seng Samban, Advisor to NCDM; Mr. Mao Saohorn, Deputy Director DoEAT/NCDM; Mr. Mam Phalla, Deputy Director DMinfo/NCDM
14 January 2022	Ministry of Agriculture, Forestry and Fisheries (MAFF)	Mr. Soeun Mak, Deputy General Director, General Directorate of Agriculture (GDA); Dr. Minea Mao, Director Department of Agricultural Extension

ANNEX

3

STANDARDS AND GUIDELINES

ANNEX 3 | Standards and Guidelines

Standards and Guidelines	Year
General Standards and Guidelines	
Natural Hazard Awareness and Disaster Risk Reduction-OECD Policy Handbook, 2010	2010
WMO Guidelines on Multi-hazard Impact-based Forecast and Warning Services	2015
Multi-hazard Early Warning Systems: A Checklist	2017
Disaster Risk Knowledge	
Guidelines on the Definition and Monitoring of Extreme Weather and Climate Events	2015
Guidance for Recording and Sharing Disaster Damage and Loss Data	2015
Detection, Monitoring and Forecasting of the Hazards and Possible Consequences	
Guidelines on early warning systems and application of nowcasting and warning operations	2010
WMO Manual on the Global Data-processing and Forecasting System: Annex IV to the WMO Technical Regulation	2017
WMO step-by-step Guidelines for Establishing a National Framework for Climate Services,	2018
Manual on Marine Meteorological Services - Volume I	2018
Warning Dissemination and Communication	
WMO Guidelines on Improving Public Understandings of and Response to Warnings	2002
WMO Guidelines on Cross-Border Exchange of Warnings	2003
WMO Guidelines on Weather Broadcasting and the Use of Radio for Delivery of Weather Information	2005
WMO Guidelines on Communicating Forecasting Uncertainty	2008
WMO Guidelines on International and Cross-border collaboration in the warning process	2011
WMO Guidelines for Implementation for Common Alerting Protocol (CAP) Enable Emergency Alerting	2013
Preparedness and Response Capability	
WMO Guidelines on Integrating Severe Weather Warnings into Disaster Risk Management	2005

Annex 3: Standards and Guidelines

WMO Guidelines in Quality Management Procedures and Practices for Public Weather Services	2005
WMO Public Weather Services Strategy for Developing Public Education and Outreach	2006
WMO Guidelines in capacity building strategies in Public Weather Services	2007
UNISDR Disaster prevention for schools: guidance for education sector decision-makers	2008
UNISDR School emergency and disaster preparedness: guidance notes	2010
WMO Guidelines for Creating a Memorandum of Understanding and a Standard Operating Procedure between a National Meteorological or Hydrological Service and a Partner Agency	2012
WMO Guide to Implementation of Education and Training Standards in Meteorology and Hydrology, volume I - Meteorology	2015
Other Key Guidelines	
Guide to Climate Watch System Early Warning against Climate Anomalies and Extremes	2006
Guide to Drought Monitoring and Early Warning: Concepts, Progress, and Future Challenges	2006
Guide to Flood Forecasting and Warning	2011
Guide to Management of Flash Floods	2012
Guide to Agricultural Meteorological Practices	2012
Standardized Precipitation Index User Guide	2012
Handbook of Drought Indicators and Indices	2016
Guide to Use of Climate Predictions to Manage Risks	2016
Guidelines on Nowcasting Techniques	2017
Guide to Storm Surge Forecasting	2018
Step-by-step Guidelines for Establishing a National Framework for Climate Services	2018
Global Guide to Tropical Cyclone Forecasting	2019

For more information, please contact :

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