# Driving Factors on Flood in Cambodia

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Contributor: Sophea Rom Phy , Ty Sok , Sophal Try , Ratboren Chan , Sovannara Uk , Chhordaneath Hen , Chantha Oeurng

Flooding in Cambodia, divided into riverine and flash floods, is subject to a multitude of common driving factors. As the MRC rightly noted, flooding in the country can be aggravated by numerous factors, including but not limited to climate change, infrastructure development, dam construction, land cover/use change, or land clearing.

flood hazard driving factors Cambodia

## 1. Climate Change

A growing number of researchers have been investigating the impacts of climate change on floods in major watersheds, that is, the MR and TSL basins. As strongly remarked by the Royal Government of Cambodia (RGC), this stems from the fact that Cambodia is highly susceptible to climate change, given the country's low adaptive capacity, yet high dependence on climate-driven resources [1]. The mean annual temperature will rise from 1.4 to 4.3 °C which induces an upward trend in average annual rainfall, especially during the rainy season [2] as well as spurs the unpredictability of weather patterns [3]. This unequivocal phenomenon will increase the frequency, duration, and severity of flood inundation, as a result of rising peak discharges in most streams, thereby leading to a more pressing future of flooding in Cambodia [3].

Oeurng et al. [4] and Try et al. [5] corroborated the alteration in peak discharge and flood inundation in the TSL Basin under certain climate change scenarios whilst climate change will enlarge flood extent and increase water level [6]. Given that TSL is governed by the monsoonal flood pulse, major modifications in this basin have been anticipated along with its consequences on the whole ecosystem, including forests, wetlands, and aquatic ecosystems [7][8][9][10][11]. Other local watersheds are on course to deal with this climate change as flooding patterns diverge from the baseline and thus become more frequent and severe. For example, peak flows tend to rise dramatically in the 3S Basin by over 50% in the 2060s due to climate change [12]. Moreover, it is generally perceived that climate change triggers other factors such as failures of flood mitigation structures including dams and embankments, and more occurrences of extreme weather events [13].

## 2. Water Infrastructure Development

The construction of dams was cited to affect flood levels in the Cambodian lowland as well as the Mekong Delta in an insignificant way; the annual flood extent between 1996 and 2000 saw a mean decrease of only 3–5%, compared with the baseline area of 38,200 $km^2$ [14]. In case of a dam collapse, flooding will turn into an unmanageable hazard, in which emergency response is of paramount importance, yet losses are woefully inevitable. The MRC also attested that should any dam failure occur along the MR, three provinces, namely Stung Treng, Kratie, and Kampong Cham, can be adversely threatened by flooding [13]. For instance, the major Xe Pian Xe Namnoy hydropower dam collapse in Laos in July 2018 left a devastating flash flood in the northeastern provinces of Cambodia along the MR by raising the water level in Stung Treng to 12 m, which is 0.5 m higher than the emergency level [15][16]. Thousands of Cambodians, over 100 km downstream, were displaced and forced to evacuate while rice crops were critically damaged [15][17]. Another study found that villagers in the 3S Basin incessantly suffered from floods of almost annual recurrence since 1996 due to water release in the wet season from dams in Vietnam and Laos [18]. The act is to keep dam levels below safe levels with respect to dam failure, especially during an extreme rainfall event [18].

Likewise, embankments were found to increase flooding depths as a result of the floodplain being replaced by those structures [14]. Notwithstanding flood risk management, which generally includes embankments, flooding is liable to occur as a result of floodplain loss. This is largely due to the capacity of flood water retention of the floodplain being depleted [19], which is otherwise crucial in maintaining hydrological regime and soil infiltration, reducing surface flow [20], and fostering a mosaic of ecological systems [21]. Rising water levels are inevitable when natural floodplain zones are substituted by such structures [19].

## 3. Weather Extremes

The unpredictability of future typhoons impacting Cambodia may be overlooked in the previous studies. This is largely because the country is never directly hit by typhoons and therefore, receives less severe effects from any typhoons that decay or transform into tropical storms, compared with the countries that are directly hit by typhoons. However, flash floods in over 14 provinces were logged as a result of decaying Typhoon Ketsana between the end of September and the beginning of October 2009 [22]. The aftermath left almost 4 dozen casualties, with other injuries and substantial property loss. 4 years later, two typhoons (Wutip on 26 September and Nari on 14 October) hitting the Lower Mekong Basin (LMB) transformed into significant tropical storms once they made landfall in Cambodia [23]. Almost 170 casualties were reported over the country as a result of flash floods due to these storms. That said, other than riverine flooding, flash flooding caused by tropical storms or typhoons is deemed perilous.

On top of that, the El Niño-Southern Oscillation (ENSO), comprising Neutral, La Niña, and El Niño phenomena, also plays an evident role in disproportionately affecting flooding situations globally, especially the duration of a flood event which was found to prolong [24]. Also, more intense precipitation and therefore extreme floods are attributed partially to La Niña [25]. In other words, above-average rainfall is usually expected during the La Niña period. However, some years are recorded as La Niña years or events while others are El Niño or Neutral years, both of which are of irregular occurrence, leading to another strain and uncertainty on climate variability over the region. Although La Niña often manifests as a factor in accruing flood risk, studies on these phenomena of flood inundation are not abundant enough in Cambodia [26]. Indeed, the years 2000 and 2011, during which two of the most severe flood events were well recorded in the LMB, were markedly influenced by the La Niña phase; Cambodia also underwent these two severest events, in which casualties and losses were insurmountable [27].

## 4. Land-Use Change

In addition to the above factors, flooding in Cambodian river basins is also attributed to land-use change, irrespective of any extent. The upstream part, usually occupied by forests, is central to regulating flow and averting flooding downstream. In other words, more land clearing in the upstream areas begets escalation of surface runoff, peak discharge, and flood magnitude [14]. Land-use change, usually from forests to agriculture and built-up area, brings about changes in surface roughness and a decrease in infiltration rates, which generally result in rising flood discharges [28]. The hydrological systems can be sustained unless major modifications of land cover in the highland take place. It is worth mentioning that this change is poised to continue in line with commonly known societal trends such as demographic transition, agricultural demand, and economic growth within the country. To illustrate, the transition from forest to agriculture and urban area is apparent in response to those aforementioned trends. For example, numerous forest types were transformed into agricultural and built-up areas at a rapid pace in the Stung Sangke catchment [29] and Battambang province [30]. The rates of such land conversion can be measured through in-situ and remotely sensed data, the RS and GIS approaches, and modeling to predict; however, the impact of those changes on hydrology and flooding remains to be uncovered. The uncertainty of hydrological response and flooding attributes becomes larger when the rapid land-use change is coupled with the aforementioned driving factors like climate change and infrastructure development.

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