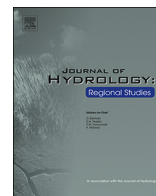


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## Journal of Hydrology: Regional Studies

journal homepage: [www.elsevier.com/locate/ejrh](http://www.elsevier.com/locate/ejrh)

## Impact of reclamation on the environment of the lower mekong river basin

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## ARTICLE INFO

## Keywords:

Watershed development  
Cambodia  
Remote sensing  
NDWI  
Multiple logistic regression  
Flood inundation model

## ABSTRACT

**Study Region:** In the lower Mekong River Basin, the watershed development, such as reclamation, has been rapidly erence water index (NDWI) were defined as going on.

The reclamation is expected to cause many problems on this important watershed environment.

**Study Focus:** The objective of this research is to quantitatively clarify the impact of reclamation on the watershed environment of the lower Mekong River Basin.

**New hydrological insights:** The locations of reclamation areas were extracted using MNDWI, NDVI and NDSI derived by Landsat data. As a result, the 49 reclamation areas covering approximately 95% of all 52 reclamation areas determined by visual extraction, were extracted.

Then, the multiple logistic regression model was constructed to find the tendency of the occurrence of reclamation and reproduce the occurrence of reclamation.

The test of goodness of fit, such as Hosmer-Lemeshow test and Nagelkerke coefficient, shows high adaptability ( $R^2 = 0.89$ ) of the probability model.

The probability of occurrence of reclamation could be explained by the distance from the Phnom Penh city and the distance from the river channels.

Moreover, the existence of reclamation areas was incorporated into the flood-inundation model and total phosphorus transportation model changing the value of the elevation and the phosphorus loading respectively.

Consequently, the inundation water level increases about 3.8 m and total phosphorus concentration increases about 0.71 mg/L around Phnom Penh in case of the reclamation of 10% of all inundation areas of Phnom Penh and Kandal province.

## 1. Introduction

Floodplains that originate from floods and the inundation of rivers are regarded as one of the most productive areas, and the floodplain's role in biodiversity and agriculture is extremely important (Junk et al., 2013). It has been reported that floods and inundation are strongly related to agriculture or vegetation in many floodplains. A study of the Amazon found that some of the most influential factors that determine the vegetation distribution and composition are the water level and flood duration in the floodplain (Worbes, 1997; Ferreira and Stohlgren, 1999; Parolin et al., 2004). In the Okavango Delta in Botswana, the plant species composition was also found to be driven by flooding, with the inter-annual flooding frequency as the main driver of herbaceous plant distribution

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<https://doi.org/10.1016/j.ejrh.2018.06.003>

Received 4 June 2017; Received in revised form 8 June 2018; Accepted 17 June 2018

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Fig. 1. Floodplain affected by reclamation in Phnom Penh, Cambodia (taken by the authors, 2016.11).

(Murray-Hudson, 2009; Murray-Hudson et al., 2011). In the Northern Territory of Australia, a strong flooding seasonality was found to be responsible for the floodplain's biophysical patterns (Bowman and McDonough, 1991; Finlayson, 2005; Warfe et al., 2011). Moreover, in the floodplain of the Mekong River, it was concluded that canopy height and species richness of vegetation are strongly related to annual flood duration (Arias et al., 2013). In addition, Amano and Kazama showed that flooding and inundation make the soil fertile in the Mekong River Basin in light of the nutrient balance of the Mekong River's flooding water, soil and paddy rice (Amano and Kazama, 2016). This study concluded that flooding and inundation are vital concerns for the agriculture in the Mekong River Basin. Although the studies on agriculture and vegetation or material circulation in floodplains have been done as indicated above, none of them included the impact of watershed development, such as reclamation of the floodplain.

Other than above studies, a cost benefit analysis in terms of the benefit of agriculture and fisheries and the cost at the maximum flood (Kazama et al., 2003), the estimation of the amount of groundwater resources (Kazama et al., 2007), and the estimation of the risk of water-borne disease (Amano et al., 2011) have been done so far in the Mekong River Basin. However, the impact of watershed development has not been discussed in those studies yet.

Currently, according to economic and population growth, it is becoming more important and necessary to focus on watershed development in many floodplains around the world. Particularly, in Cambodia, located in the lower Mekong River Basin, industrial areas and residential areas have been expanded rapidly around the capital city, Phnom Penh and around each city with outstanding economic growth. The majority of these developed areas were initially floodplain and have been reclaimed and created (Fig. 1). Because of this urban development in the lower Mekong River Basin, the floodplain is being changed steadily recently.

The floodplain in the Mekong River Basin is extremely important, since it plays roles in agricultural, fishing, groundwater recharge and water purification.

However, the increase of land reclamation, that is the decrease of the area of this important floodplain in the Mekong River Basin, could lead to the loss of these functions and many problems. For example, reclamation increases the risk of flooding and inundation downstream because of the loss of storage. Not only the loss of the function of storage, but also the decrease in base flow caused by the decrease of groundwater, are also regarded as problems (Kazama et al., 2007). In addition, in terms of environmental issues, many problems are also concerns, such as the decrease of spawning grounds for fishes, prawns and crabs or the loss of water purification.

Under such circumstances, the impacts of reclamation have been discussed only qualitatively, and they have not been considered as serious problems by many Cambodian government officials. Recently, in the lower Mekong River Basin, the impact of dam construction and climate change on the environment of the watershed has been discussed often (Shrestha et al., 2016; Arias et al., 2014), but a study that evaluates the impact of floodplain reclamation quantitatively has not been done so far.

The quantitative evaluation of the impact of reclamation could lead to one of the guidelines of watershed development of the Mekong River Basin in Cambodia, where the development is going on rapidly.

Moreover, since similar problems are also concerns in other river basins such as the Irrawaddy River Basin in southeast Asia or the Ganges River Basin (Thi Myat et al., 2012), this research could be helpful in providing beneficial information to other river basins.

Therefore, the objective of this research is to quantitatively clarify the impact of reclamation on the watershed environment of the lower Mekong River Basin.

To achieve our goal in this research, as the initial analysis, the locations of reclaimed areas were extracted by a remote sensing analysis in the study area in Cambodia.

Furthermore, a logistic regression analysis has been done to determine the tendency of reclaimed land to be located in the floodplain. Then, a probability model of the occurrence of reclamation was developed in the study area.

Based on the results of the probability model, the distribution of reclamation in the future was shown in the study area, and the

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