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Drivers of vulnerability to wetlands in Punarbhaba river basin of India-Bangladesh

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ABSTRACT

Wetland degradation and loss of wetland is one of the emerging challenges against sustaining such worthy environmental capital having plenty of goods and services. In Barind tract of India and Bangladesh, such trend of wetland conversion is highly explicit. Present paper attempted to capture such trend of wetland loss, conversion of wetland and their associated reasons behind. At present total wetlands area of the basin is 220.9 km^2 and which is 35.78% lower than pre-dam wetland coverage. Flow modification triggered by Komardanga dam (34.35% for average flow and 52.24% for peak stream flow have declined) is emerged as one the major reasons behind wetlands loss. It also causes reduction of active flood prone area by 39.72% as well as inconsistent water service to wetlands. De-linking of Punarbhaba river system from Tista river system is another historical cause behind lowering of flow and flood magnitude in Punarbhaba. Loss of tie channels is also responsible for irregular water service to the wetlands. In last 30 years, about 100 km^2 of wetland is transformed into agricultural land, which points out the responsibility of agricultural extension for wetland deterioration. So, periodic monitoring of wetlands, release of ecological flow and stop agricultural encroachment are necessary for sustaining wetland.

1. Introduction

Wetlands are integral part of the socio-ecological set-up of any region (Gain and Giupponi, 2014, 2015) which project unique hydrological, ecological characteristics of the concerned landscape (Constanza et al., 1997) and provide worthy goods and services (Mitsch and Gosselink, 1993). In developing countries, wetlands are still considered as wasteland due to the unconsciousness of the people about wetland potentials (Pal, 2011) and deficiency of the techniques of wetland uses. Despite of covering only 6% of the Earth's surface (Mitsch and Gosselink, 1993; Mitsch, 2010), wetlands provide 40% of global ecosystem services (Zedler and Kercher, 2005). UNEP (2011) described wetlands as potential natural capital towards the pathway of green economy and sustainable development. In the phase of huge carbon emission and global warming, wetland can as carbon sink (Liu et al., 2014).

Despite of immense ecological importance of the wetland, intense anthropogenic pressure has converted these landscapes into agriculture and built up lands (Pal and Osoundu, 2009; Xie et al., 2009). The causes of wetlands loss e.g. agricultural extension, urban expansion (Millennium Ecosystem Assessment (2005)), excessive ground water withdrawal (Pal and Osoundu, 2009), water regulation through dam, loss of connective rivers with main river and wetland in the flood plain area (Pal, 2015) etc. are well documented in varied spatial scale. In total, approximately 50% of the world's original wetland area has not been in existence, ranging from relatively little losses in boreal countries to extreme losses of more than 90% in parts of Europe (Mitsch and Gosselink, 2000). Wetlands that are existing, whether in the developed or developing world, have been experiencing increasing pressure from both direct and indirect human activities; and despite of many countries have strong regulatory protection, wetland area and its condition continues to decline (National Research Council, 2001; TEEB, 2013).

Monitoring of wetlands dynamics using remote sensing and GIS technology is widely used for detecting and delineating surface water and its dynamics in recent decades (Xu, 2006). In the subtropical monsoon region due to having high degree of seasonality, wetland characters are highly dynamic (Gopal, 2013; Borro et al., 2014) and therefore quite difficult to identify (Li et al., 2015; Mondal and Pal, 2016). Seasonal characters of wetland is strongly determined by water spilling from the nearby rivers (Ward and Stanford, 1995; Walker et al., 1995), ground water connections (Lambs et al., 2002) and rainfall regime. In the present study region, there is no micro spatial wetland map specially those are seasonal in behaviour and people are frequently entered into the seasonally dry wetland for cultivation. The mapping of seasonal floodplain wetland is a fundamental requirement to monitor it (Thomas et al., 2011). Borro et al. (2014) rightly stated that multi-dated

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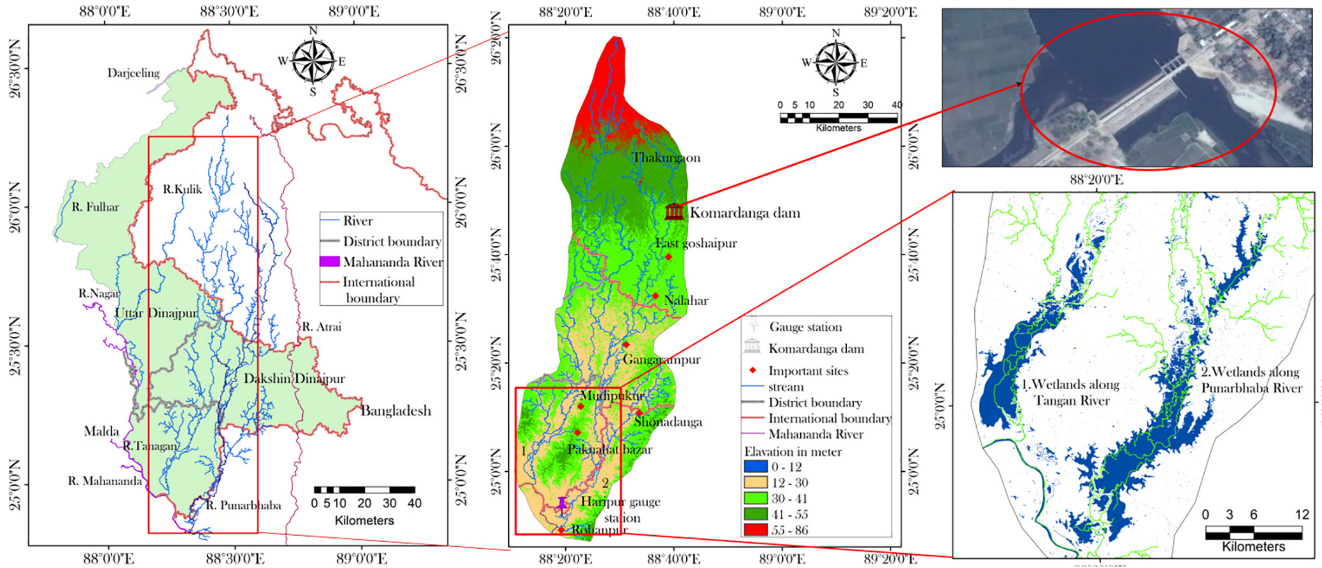

Fig. 1. Representing the study area (Punarbhaba river basin), drainage network and rain gauge station, wetlands along river and location of reservoirs over the elevation map.

image analysis could provide credible result. The main aim of the present work is to investigate the principal drivers for wetland conversion and loss.

2. Study area

Punarbhaba River (length: 160 km. area: 5265.93 sq. km.) basin is a sub basin of Mahananda River situated mainly on Barind tract of India and Bangladesh. Elevation of the basin ranges from 89 meter (at the source region) to 12 m (at the confluence) (Talukdar and Pal, 2016) (Fig. 1). The Punarbhaba lies on Tista Fan and is characterized by single channel meander. However, this river becomes multi-channel and anastomosed river system within the valleys. The Punarbhaba River experienced low to moderate sinuosity, which specifies a sloping surface of the area. But, the sinuosity of Punarbhaba River increases suddenly within the valley. Flat topography of the valley is the reason for anastomizing the channel and sudden increase of sinuosity. The Punarbhaba valley does not continue up to the confluence i.e. Mahananda river. The valley might be obstructed and did not preserve the continuity because of the area near Mahananda River is gradually uplifted and obstruct the Tangon and Punarbhaba valleys that results the formation of anastomosed pattern in river which indicates that all these are structurally controlled. A great numbers of abandoned channels, channel scars, scrolls, loops, ox-bow lakes etc. are present in these valleys (Rashid et al., 2015) indicating structural deformation. The area falls under monsoon climate with strong seasonality. Total annual rainfall in this area is 380.24 mm. The average pre-monsoon (March–May) rainfall is 14.46% to annual rainfall, monsoon (June-–September) is 70.16%, and post-monsoon (October–December) is 12.24%. No significant trend of rainfall is identified over the study area since 1978–2016. Depression storm in this time brings huge rain within a very short period and causes the flood. For taming river flow, Komardanga dam (1992) has been installed over Depha river, a major contributing tributary of Punarbhaba river. Embankment along the river in some parts of the lower catchment is found for controlling the flood.

Fig. 1 representing the study area (Punarbhaba river basin), drainage network and rain gauge station, wetlands along river and location of reservoirs over the elevation map.

3. Materials and methods

3.1. Data used

Landsat-TM satellite images represent precious and incessant records of the earth's surface during the last three decades. Such images can be used for monitoring physical features of the environment (El Bastawesy, 2014). LANDSAT 4-5 TM and LANDSAT 8 OLI have been collected from the US Geological Survey (USGS) for wetland detection and land use monitoring (Table 1). Ground water level data of Central Ground Water Board is used. Agriculture intensity is measured from the cropping area and crop frequency data collected from the District Statistical Hand Books. Daily water flow data (1978–2015) of Punarbhaba and Tangon river basin is obtained from concerned river gauge stations (Haripur Gauge station over Punarbhaba River, Malda and Bamangola gauge station over Tangan River) for analyzing seasonal hydrological character in reference to the installation of dam and simulating 2D hydraulic model.

3.2. Methods for wetland detection and assessment of vulnerability

NDWI (McFeeters, 1996), is used for delineating water body from images and Das and Pal (2016) suggested NDWI is the finest fitted method for water body extraction of the Barind tract. Yearly NDWI maps for pre and post monsoon seasons have been composited for both pre and post dam periods. For assessing accuracy of wetland mapping, 123 sites have randomly been selected from wetland area as imaged in the NDWI maps and compared with actual condition.

Table 1
Frequency configuration of the dataset employed for pre and post monsoon season during pre and post dam phases.

Season	Pre dam phase (1980–1992)	Post dam phase (1993–2015)
Pre monsoon	1980, 1982, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992 Total frequency = 11	1993, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2004, 2005, 2006, 2008, 2009, 2010, 2014 Total frequency = 17
Post Monsoon	1980, 1982, 1983, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992 Total frequency = 11	1993, 1994, 1996, 1999, 2000, 2003, 2004, 2006, 2008, 2009, 2010, 2012, 2014, 2015 Total frequency = 18