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E-Mail: seforum2004@gmail.com Post Box: **131 Guwahati GPO**

President	Secretary	Office Address
Er. A.N.N.I. Laskar	**Er. Niranjan Kakati**	Lachit Nagar, Bye Lane-7, Sub Lane-2
e-mail: annilaskar@gmail.com	e-mail: nkakati48@gmail.com	"SAPTARSHI", Guwahati-781007
M – 9435062116	M – 9435145262	

No. SEF/2019 Dt. 18.02.2019

Dear
Dr. Sarma

Your paper has been selected for publication in Techl. Volume cum Souvenir.

May we request you to present the paper on 20 Feb. 2019 at 10 AM in technical session. The venue is Institution of Engineers (I), Panbazar, Guwahati.

K.G.DebKrori
Chairman, Techl. Committee

FLOODPLAIN WETLAND MANAGEMENT: A TOOL FOR FLOOD CONTROL

Prof. (Dr.) Arnab Sarma
Head, Dept. of CE, RSET, RGU

Abstract

Wetlands are often drained, filled up and eventually destroyed in the process of urban development and needless to say this has been a part of civilizations, both past and present around the globe. This is because we human beings have placed ourselves at the centre of all the species on this planet due to our having a false notion of supremacy. On one hand we talk of wellbeing and on the other we lack sensitivity to our natural environment from which we derive all the resources to sustain wellbeing. Wetlands are one of the many natural environmental entities that play an immense role in terms of providing ecosystem services. Recognizing this fact the Convention on Wetlands of International Importance was held in the city of Ramsar, Iran in 1971 and an international treaty for the conservation and sustainable use of wetlands was signed by various countries including India. Used by many different organisms at different stages of their lives, wetlands have been found to be one of the most productive ecosystems in the world, placing them in the same category as rain forests and coral reefs. We may therefore term wetlands as "biological supermarkets".Although wetland ecosystems are important habitat for amphibians, fish, plants, and other wildlife, this paper primarily deals with the role a well-managed wetland plays in controlling flood and mitigating its potential damage.This paper examines the potential of Floodplain Wetland in controlling flood.

Keywords: Wetlands, floods, water storage, runoff generation, hydrology

1. Introduction

Ramsar Convention on Wetlands define wetlands as: "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres". Wetlands are typically classified as distinct entities (National Research Council, Canada 1995) since they are neither completely aquatic nor completely terrestrial. Rather, wetlands often represent a physical interface between the aquatic and terrestrial ecosystems resulting in a functional overlap (Figure 1). Wetland isolated from aquatic systems is represented in Figure 2.

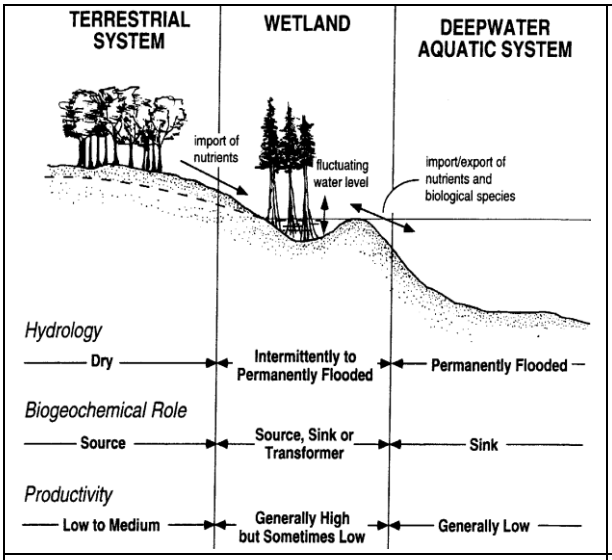


Figure 1: Functional overlap of wetland (NRC, Canada 1995)

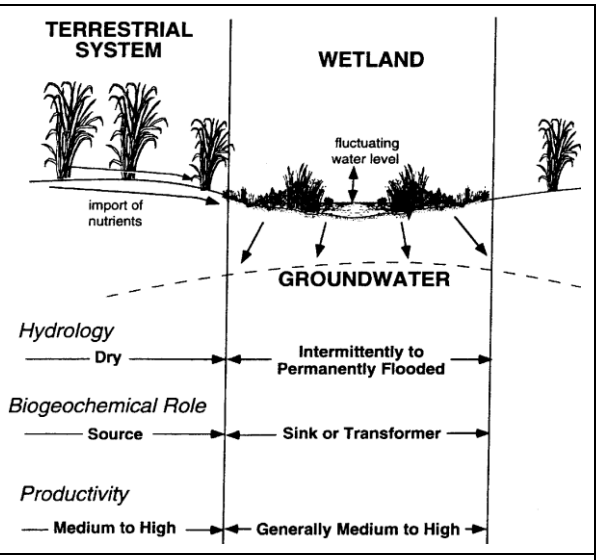


Figure 2: Wetland isolated from aquatic systems (NRC, Canada 1995)

Wetlands,differently termed as swamps, marshes, fens and bogs are natural water-storage features on the landscape. Once considered wasted land or lurking-grounds for evil at worst, wetlands are essential wildlife habitat, massive natural water filters, and "natural sponges" that hold water when it rains and then release it slowly. This is a generic statement and requires examination as the term “wetland” covers many land types, including wet woodlands, reed beds, peat bogs, fens, and salt marshes (M. Acreman & J. Holden, 2012). Each of these wetland types can have a hydrological function that is subtly different, making it difficult to generalize the

flood reduction services of wetlands. A clear distinction is visible as Upland Wetlands generally tend to be flood generating areas while Floodplain Wetlands have a greater potential to reduce floods although, landscape location and configuration, soil characteristics, topography, soil moisture status and management all influence whether or not these wetlands provide flood reduction services. Wetlands within and downstream of urban areas are particularly valuable, counteracting the greatly increased rate and volume of surface water runoff from pavement and buildings. The holding capacity of wetlands helps control floods and prevents water logging of crops. Preserving and restoring wetlands together with other water retention can often provide the level of flood control otherwise provided by expensive dredge operations and levees. The bottomland hardwood- riparian wetlands along the Mississippi River once stored at least 60 days of floodwater. Now they store only 12 days because most have been filled or drained.

Particularly during the last 100 years, huge areas offloodplain have been drained and cut off from their riversby artificial embankments (termed bunds, dykes or leveesin different countries). This means water that used tospread out slowly and relatively shallowly across broadfloodplains is now concentrated into ever-smaller areas.As a result, floods are deeper and more likely to causedamaging (sometimes catastrophic) impacts if andwhen artificial flood banks are breached. This is almost a recurrent phenomenon in the state of Assam. Studies reveal that in the middlereaches of the Yangtze River, China for example, flooding hasbecome more frequent and more damaging as a directresult of floodplain loss, especially when combined withthe loss of vegetation cover in the river's drainage basin. All the aspects discussed in this paper need immediate attention of the Government agencies to explore the possibility of wetland management especially for the wetlands located in the floodplains of Assam.

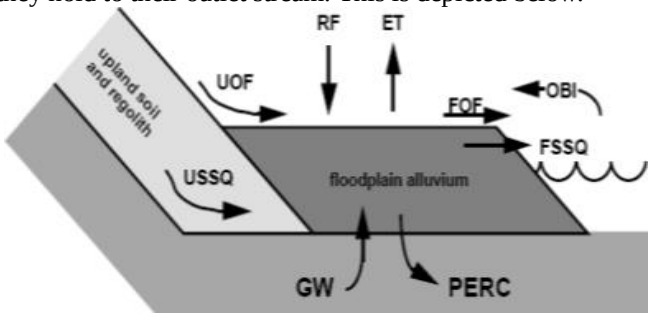
2. Dynamics and Functions of Wetlands

Wetlands are one of the most dynamic and productive ecosystems found on this planet andit is reported that they produce more plant and animal life than woodlands or prairies of the same size.They are dynamic because they undergo changes, both seasonally and annually (dry up and get flooded) but still maintain the ecosystem equilibrium.These natural processes don't harm the wetland. On the contrary, theseinteractions make wetlands so productive.If this dynamic nature is stalled, for example, by maintaining constant water levels, a wetland can begin to deteriorate.Loss of dynamism of a wetland can also be attributed to other factorssuch as permanent drainage, filling with soil, concrete or trash, diverting water or erosion.

There is a plethora of beneficial functions that a wetland plays, which often go unnoticed.They are particularly valuable components of the ecosystemfor fish and wildlife, as well as for protecting water quality, erosion prevention, flood storage and recreation. Due to their power of natural pollution control and filtration of sediment from runoff they help prevent mud from clogging lakes and reservoirs downstream. Generally speaking, wetlands retard water flows and this reduces downstream soil erosion.Further, wetlands located on floodplains and in coastal areas, function in aiding flood control by storing excess water during storm events.Wetlands temporarily store water, allowing it to percolate into the ground or evaporate. This can reduce peak flooding after a storm.With regard to water quality functions, wetlands can remove up to 90% of nitrates. By trapping sediments wetlands can keep away large amounts of phosphorous from entering adjacent rivers.

3. The Balance

Wetlands typically have a large inlet and a small outlet i.e. they receive water from a wider area as compared to the area to drain out.Some of the trapped water returns directly to the atmosphere through evaporation or plant transpiration, and while few wetlands recharge groundwater, they slowly release the water they hold to their outlet stream. This is depicted below.



INPUTS:
UOF = Overland flow from upland slope
USSQ = subsurface flow from upland slope
RF = precipitation directly onto flood plain
GW = Groundwater discharge from bedrock,
BS = seepage from river channel through banks
OBI = overbank inundation.
OUTPUTS:
FOF = overland flow from floodplain to river
FSSQ = subsurface drainage to river, ET = evaporation loss
PERC = percolation to bedrock below

Figure 3: Schematic diagram of the water balance of a floodplain (Adapted from Burt, 2002)

4. The Question

Studies have sufficiently proved that floodplain wetlands reduce flooding. Then the pertinent question is “why not artificially create or restore existing wetlands to create a natural flood-control mechanism?” The answer twofold: (a) restoration can work only if the soils and water flow have not been altered too drastically (Joy Zedler)and (b) creation of artificial ones elsewhere is found to be much more problematic mainly because, unless the new wetland is in the natural stream flow, it may be worthless for reducing floods.It has been observed that many of the constructed wetlands do not work to provide natural habitat as like a natural wetland because they are yet to develop and stabilize as a naturally active ecosystem.

5. Wetlands vis-à-vis Peak Flood

For floodplain wetlandsto attenuate flood there must be two potential areas of water storage; first, in hollows/depressions on the surface and second, within the soil pores. Undulating topography is required to produce hollows, and unsaturated soil is required to provide room for soil water storage, so that the wetland can store precipitation before saturation-excess overland flow is generated (M. Acreman &J. Holden, 2013). Moreover, after very dry weather, even if there is storage capacity within the wetland, peat in many wetlands can become hydrophobic which means reduced infiltration capacity (Holden et al. 2013). This can potentially generate infiltration excess surface runoff even when there is plentiful storage capacity (due to unsaturated condition) within the wetland. Nevertheless, this effect seems to be restricted and typical surface infiltration rates in wetlands are high when the water table is not at the surface (e.g. Holden and Burt 2002a).

5.1 How upland rain-fed wetlands relate to flood processes

To reduce floods in upland catchments, where river flow is generated, the water level in the wetland needs to besufficiently low to have enough capacity and responsivenessto store water rapidly. However, it is observed that low water tablesare not common in such upland wetlands and frequent saturation occurs due to high rainfall in upland areas. As a result, these upland wetlands rarely act to attenuate flood flow. Rather, such wetlands contribute to storm runoff due to theirpropensity for rapid saturation (Price 1992). McCartney (2000) studied small upland wetlands in Zimbabwe that are protected because they are assumed to reduce floods and augment low flows. He found that saturation-excess overland flow, arising within the wetlands, was the principal mechanism of storm discharge generation. The wetlands studied had small capacity to absorb rainfall at the start of the wetland season, when water table levels are low, but soon became saturated and contributed to flood runoff thereafter.

5.2 How floodplain wetlands relate to flood processes

Downstream wetlands, particularly floodplain wetlands, have a greater potential to reduce floods due to lesser degree of soil saturation as opposed to upland wetlands. Many of the floodplain wetlands are in closed/confined hollows in the landscape. Whilst they may capture and hold local rainfall and runoff, they are not in direct connection with rivers and so have little influence on river floods as such but can act as retention basins for a longer time allowing water to infiltrate. It is also observed that downstream/floodplain wetlandsare often relatively dry before a flood and so providewater storage during the flood. Relative impact of wetlands and management regimes on floods is depicted in Figure 3.

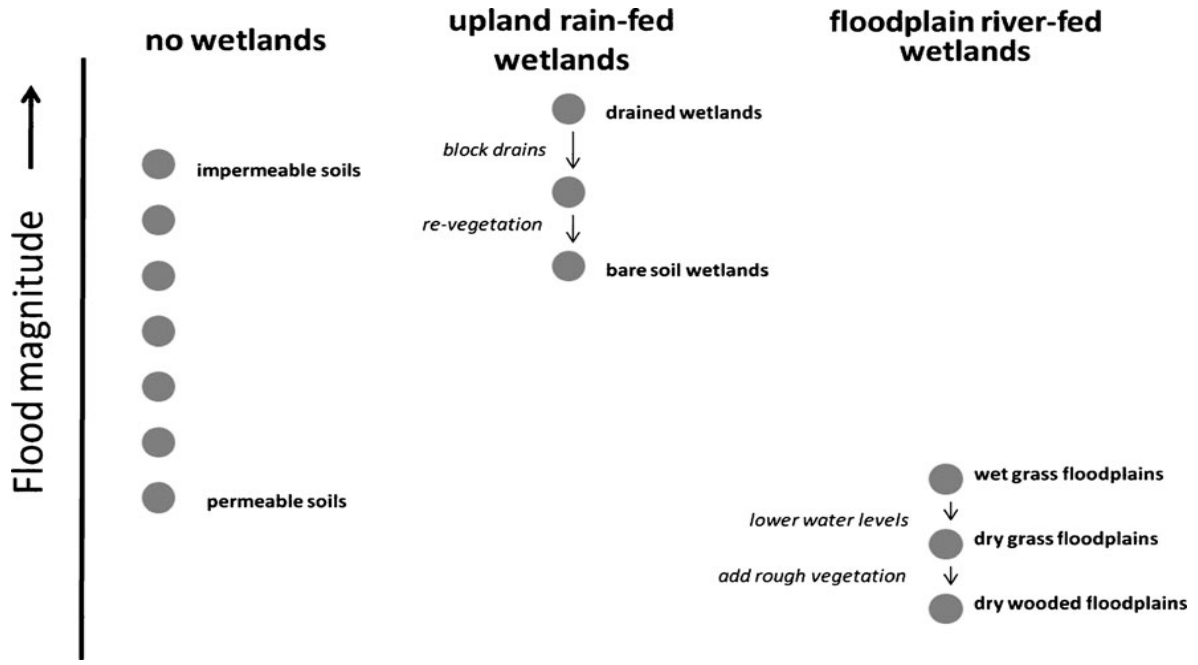


Figure 4: Relative impact of wetlands and management regimes on floods
(M. Acreman &J. Holden, 2013**)**

Conclusion

Generally speaking, wetlands act as natural sponges, soaking up and holding storm water until it can infiltrate into the ground. Whatever water does not infiltrate into the groundwater is slowly released into nearby streams by the wetland. This slow release helps prevent flooding during storm events. The vegetation in wetlands also helps reduce the speed of water as it flows over the landscape. In combination, floodplain wetlands provide immense water storage benefits while slowing water to reduce the height of floods and erosion rates. In urban areas, downstream wetlands can help filter out dangerous pollutants as well. In effect, wetlands counteract the harmful impacts development has on watersheds.In watersheds with high levels of wetland loss, peak flooding increases by as much as 80%. Coupled with the flashy impacts of impervious surfaces and urban development, this figure can be pretty troublesome. Studies show that preserving natural wetlands is most likely more economically efficient than draining the wetlands, installing grey infrastructure, and maintaining this infrastructure to prevent flooding. Constructed wetlands rarely function as efficiently as natural wetlands. When a natural wetland is drained, the soil and water flow patterns are usually changed. Constructed wetlands have to be carefully placed to drain into the natural stream flow as well as to capture incoming runoff. The valuable habitat provided by natural wetlands is often lost, even during construction of new wetlands.

In relation to flood management, water levels and flooded areas (water spread) in wetlands can be controlled by manipulating the stage-discharge relationship. On the ground, this can be done by changing the elevation of an outflow structure e.g. by raising the base of an outlet weir elevation. The base elevation, along with the rate of change in discharge with elevation, can be adjusted using outflow structures of different sizes and shapes, depending upon the desired outflow characteristics. Some of the other hydrologic alterations possible in this regard are closing of ditches and drains, which would in turn reduce outflows and increase the storage volume. This (increased storage and spread) can further be supplemented by removing obstructions such as roads and berms constructed within the wetland as this would recreatethe natural hydrologic communication with neighboring waterbodies.Regardless of whether impaired wetlands are being restored or new wetlands are being created, the intent is to recreate the hydrologic behavior that we find so important (Greeson, et al.1979).

Although wetlands can be considered a classic example of natural flood control, but just because wetlands can store water, they are not a panacea. In a major flood, just like a dam, wetlands can get filled up, after which, incoming water simply runs off albeit at a reduced height. So while wetlands can help reduce the size (discharge) of minor floods, in giant floods, they may only reduce flood height, which itself is a great relief. Finally, for effective management of floodplain wetlands, the factors to be considered are “landscape location and configuration”, “topography”, “soil characteristics”, “soil moisture status”, “management practices”. And the strategies proposed should be within the ambit of the Wetland Rules notified by the government from time to time, the latest being the Draft Wetland Rules 2016. However, comparison of the Wetland Rules 2010 with the

Draft Wetland Rules 2016 reveals that the later offers very few protective measures to Assam's wetlands when compared to the 2010 Rules. Experts have opined that many important provisions which were included in 2010 have now been removed from the new Draft rules. This calls for a complete revision of the Draft Wetland Rules 2016 to ensure better Wetland management and conservation in the state of Assam, which boasts of having more than 3000 floodplain wetlands of various sizes each playing unique role.

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