Impact of Forest Intervention on Water and Soil Quality- Case Studies

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Abstract— Forest affect the hydrology of watersheds in various and complex ways, by increasing evapo-transpiration, increasing infiltration, intercepting cloud moisture, reducing the nutrient load of runoff, and more. Even dry deciduous forests, which receive less rainfall, serve as natural filter and maintain the water budget throughout the year. This study highlights the brief remarks on dry deciduous forest through intervention on water and soil. In this field research study, an attempt is made to assess the quantum of the stream flow and to check the water quality and soil texture with reference to study area related to maintenance of forest hydrology. Results showed that the deciduous forest reduced the magnitude of peak discharge during rainy months and ultimately forest controls excess runoff in the downstream. Thus forests induce infiltration which leads to more uniform flow round the year. The water quality results indicated that the suspended solids as well as coliform and fecal coliform are reduced substantially prior to forest lands compared to disturbed forest. It is also observed that soil cover may be favourable in terms of amount of nutrients for the plant growth in the disturbed catchment.

Keywords— carbon content, deciduous, forest, water, soil.

I. Introduction

In present the world is going to face severe water crisis, especially crisis of portable and drinkable water. About 2.8 billion people of 48 countries will face severe water stress(Water.org).About 884 million people are not able to have clean and save water. It was found that contaminations of pollutants only from non-point sources was estimated about $7 to $9 billion a year in the mid 1980s [1]. The natural and safe way to protect the water from pollutants is forest. Forest can protect water from sedimentation, nutrition accumulation and enhance the water quality [2]. Pathogens such as waterborne bacteria, viruses, and protozoa are the source of many diseases, including salmonellosis, mastitis, scours, anthrax, tuberculosis, brucellosis, tetanus, and colibaciliosis, that infect humans, livestock, and other animals[3]. Scientists found that deciduous hardwood riparian buffers removed about 80% phosphorous from agricultural run-off in Mary land [4].

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Not only that, the forest also controls the water supply throughout the year and forest plantation affect the peak-flow of different river basin [5]. It is well established that grassland and cultivation, in the place of forest, primarily increase the quantity of water but cannot control the water balance throughout the year. It is proved that different plant species need different quantity of water and thus affect the water sources and its' quality [6]. It is increasingly recognized that both the availability and the quality of water are strongly influenced by forests and that water resources in many regions are under growing threat from overuse, misuse and pollution. The relationship between forests and water is therefore a critical and important issue that must be accorded high priority.

So forest provide the surroundings safe water and also protect the surroundings from extreme natural calamities like flood, drought etc. In this regards, forest management and protection is also an important factor. The surroundings forest dwellers are not only get the facilities concerning water but they depend on forest products for their livelihoods. Value of such environmental services and non timber forest product is difficult to determine. The contingent valuation method is one of the best method to determine the value of environmental services [7]. The total value for forest ecosystem goods and services was estimated around $4.7 trillion annually by Coatanza et.al [8]. A review paper was prepared on the economic value of forest ecosystem services by Kringer [9], and he divided the forest valuation paper into eight categories-Watershed services, soil stabilization, erosion control, air quality ,climate regulation, carbon sequestration, biodiversity, recreation and tourism, non-timber product and cultural values. But the valuation of forest product is not enough, the use of valuation through policy and market creation is also necessary [10] to assess the total economic value of forest resources in Turkey, a total value including direct, indirect, option and existence values are accounted [11]. Bishop [12] focused on recent advances in the economic evaluation of forestry activities, specially valuing non timber forest benefits and associated development of forest policy and management system. The monetary contributions of forests to the economies of the developing world exceed US$205 billion annually [13]. So it is evident that forest is the most valuable resource of nature and by only protect it water and the human civilization can be protected in future.

II. Material and Method

A. *Case Study of Bankadaha Forest*

The present study tries to identify the relation between forest and water and try to establish an agreement among forest, water and soil. Beside this, the study also focuses on the valuation of the forest to identify the importance of forest management and the participation management of forest as an effective management technique. For study area, a dry deciduous forest of western part of West Bengal—Bankadaha forest was selected. Bankadaha forest is located in Bankura district, under Panchet division. The total Bankadaha forest covers an area of 9021 ha., from which 7304.52 ha. area is under protection. The forest is located on the plain land of river Kangshabati. The Mukutmonipur canal is running through this forest from north-east to south-west of the forest. physiographically, it is located on Ruhr plain and has undulating terrain. The forest is covered with Sal and its' associates like Amlaki, Haritaki, Bohera etc. The main species is Sal. This forest is located near Bishnupur and is rich in valuable timber and non-timber products. The Bankadaha forest has 5 Beat Office namely- Bankadaha, Amdangra, Peardoba, Uparsole and Amdhara. There are near about 80 villages located in the forest. At present 62 villages have Forest Protection Committee to protect the valuable wealth of the forest.

At first the water bodies and important villages in and around the forest were located. The locations of sampling were chosen. The water and soil samples were collected from three major areas- inside the forest area that is undisturbed forest catchment, Peripheral side of the forest area that is semi –disturbed forest catchment and outside of the forest that is disturbed catchment. A numbers of water quality parameters were tested like pH value, Turbidity, NTU, Total Suspended Solids, Biochemical Oxygen Demand, Total Hardness, Total Nitrogen, Total Phosphorus, Total Coliform etc. Soil quality parameters like pH value, Soil Carbon, Total Nitrogen, C: N ratio, Exchangeable Ca, % of Base Saturation etc. was also tested seasonally. The water samples were examined by APHA 21st Edition. The water and soil samples were analysed and compared seasonally and spatially. Beside this, Contingent Valuation Method (CVM) is applied. CVM is a survey technique using direct questioning of individuals to generate estimate of one's willingness to pay for something they value- in the case of forest it would be better forest management. Alternatively, individuals might be asked how much compensation they would require if they no longer had to access to the forest for their daily use. It is a vast used method to evaluate the non-use value like environmental value or biodiversity value of forest. CVM was applied by other researchers in order to assess non-use value of two UK wetlands. At the same time we used the Stated Preference method in our study. Through this methodology we can assess the water and soil quality and with the same time the better management for the forest can be determined.

B. *Case Study of Neora Valley*

The Eastern Himalaya is one of the richest, pristine, ecological regions in the whole world. In West Bengal, Darjeeling is located in the Eastern Himalayan region and is accounting 38.23% of total forested area. Among the virgin forest area of Darjeeling district, the pristine forest of Neora valley National park is on Kalimpong hills. The Neora Valley National Park was been included in the shortlist of World Heritage sites in May 2009 [14]. This forest is recognised as one of the 25 Global Hotspots (Myers et.al, 2000); one of the 200 global forest eco regions (Olston and Dinnerstein, 1998). Neora Valley National Park is located in the Bio geographic province 2C of the central Himalayas (Rodgers et.al.2002). The park spreads over 88 km2, located between latitudes 26°52'03"N-27°7'35"N and longitudes 88°45'E-88°50'E; however, the actual surface area available to the wild denizens is, in fact, much greater owing to its undulating terrain. The highest point is Rechila danda peak (3,170 m) bordering Sikkim.It is also an ecological trijunction with Sikkim and Bhutan and one of the oldest reserve forest in India [15]. Neora Valley forest includes the catchment and watershed of the Neora river and with its' sixteen subsidiary streams and nine main feeder streams. The Neora river provide water to the adjacent village and town of the forest.

At first the water bodies and important villages in and around the forest were located. The locations of sampling were chosen. The water and soil samples were collected from three major areas- inside the forest area that is undisturbed forest catchment(Mulkharka), Peripheral side of the forest area that is semi –disturbed forest catchment (Chaudapheri Forest Camp) and outside of the forest that is disturbed catchment (Lava). A numbers of water quality parameters were tested like pH value, Turbidity, NTU, Total Suspended Solids, Biochemical Oxygen Demand, Total Hardness, Total Nitrogen, Total Phosphorus, Total Coliform etc. Soil quality parameters like pH value, Soil Carbon, Total Nitrogen, C: N ratio, Exchangeable Ca, % of Base Saturation etc. was also tested seasonally. The water samples were examined by APHA 21st Edition. The water and soil samples were analyzed and compared seasonally and spatially.

III. Result & Discussion

A. *Water Quality of Bankadaha Forest*

Water quality of different catchment was tested seasonally and analyzed and compared spatially. It was found that the pH value of surface water inside the forest is between 7.1-7.64 which is near around the neutral value. The pH value of ground water in the forest is 5.2-5.5 which indicates the presence of acidic element in ground water. The pH value of surface water outside the forest catchment is from 7.23-8.15, that implies water has basic elements The turbidity is high in surface water inside the forest. The turbidity of surface water ranges from 11.3 NTU to 668 NTU. But the turbidity of

ground water is lower, about 0.15-0.92 NTU. The turbidity of surface water outside the forest is around 41.3-49.7NTU.The total dissolved solids (TDS) is around 42-62mg/l. The amount of TDS is higher in surface water outside the forest. The amount of The Biological Oxygen Demand (BOD) of surface water inside the forest is less than2.00 to 5.5 mg/l. But the BOD is higher in pre monsoon than post monsoon. Whereas the BOD of groundwater is less than 2mg/l. The BOD of surface water outside the forest is more than 6mg/l. The total hardness and total alkalinity in surface water inside the forest is lower than outside the forest. The amount of total coliform in surface water ranges from 220-1600 MPN/100ml. The amount of fecal coliform in surface water is also varies seasonally from 24-22- 170 MPN/100ml. The ground water quality inside the forest or disturbed catchment is very good. The surface water quality parameters like turbidity, BOD, total hardness and total alkalinity, total and fecal coliform change with season .The water quality deteriorates with the change of forest catchment.

TABLE 1. ROLE OF BANKADAHA FOREST SPECIES IN MAINTAINING FOREST-WATER-SOIL RELATION

Name of the species	% of Carbon, Hydrogen & Nitrogen of Bankadaha Forest Species		
	Carbon (%)	Hydrogen (%)	Nitrogen (%)
Sal	46.42	5.86	1.83
Bohera	43.77	5.25	1.66
Mohua	47.27	6.14	1.68

B. Soil Quality including Major Forest Species of Bankadaha Forest

The soil samples were also collected in different season from different catchment i.e. disturbed, semi-disturbed and undisturbed. The pH value inside the forest is near to neutral value, but turns towards acidic value in uncontrolled forest catchment area. The pH value also varies seasonally from 5.10-7.22. The percentage of soil carbon is higher inside the forest than outside the forest. The soil carbon is also varies from 0.26% in pre monsoon to 0.59% in post monsoon. The amount of total nitrogen is lower in semi disturbed forest catchment than disturbed and undisturbed forest catchment. The total nitrogen varies seasonally from 146.9-689.1 g/kg. The C : N ratio also varies from 9.52-14.28. But the C : N ratio also high inside the forest and is lowest in the semi-disturbed forest catchment. Available potassium also significantly varies from 3.8mg/kg in pre monsoon to 36.8mg/kg in post monsoon. The Cation Exchange Capacity meq/100gm is higher inside the forest than disturbed and semi disturbed area. The Base saturation (%) is higher in semi disturbed forest and lowest inside the forest. The exchangeable Calcium (meq 100g/m) is higher inside the forest but the exchangeable Sodium (meq 100g/m) is higher outside the forest. The exchangeable Potassium is higher in semi disturbed area. Table 1 showed that the maximum percentage of carbon content is found to be 47.27% in case of Mahua species. Total soil carbon and soil organic carbon stock in the study area can be estimated by knowing bulk density, area and depth of soil collected at field level and also the amount of carbon sequestration can be estimated by all sampled species in the study area.

C. Contingent Valuation Method

There are two parallel slow sand filters. The length, We applied contingent Valuation method to measure the importance of the forest to the forest villagers and nearby villagers. We asked the villagers that how much they can give for the management of forest in exchange of goods and services they get from the forest. The forest villagers are very poor. Most of them have income below Rs. 5000 per month. So they are not able to bear such expenditure per month. Some of them agreed to give Rs.20 per month for the management of the forest. But most of them did not agree to spend money for this purpose. In exchange of money they agreed to give their labour and time to protect the forest and wanted to involve directly in forest management. In return they did not want any wage. This is the most valuable thing in human life. Everyone wants to give time, love, labour to their family, to whom they love most. But the villagers want to spend their time, labour to the forest. This is the proof, that they love the forest most.

Outside the forest the nearby villagers agreed to give Rs.20-50 for the management and protection of the forest. There are near about 300 populations in villages, outside of forest. Hence the total cost for management of the forest they agreed to give per year is Rs.72000-1, 80,000. Ultimately it is proved that the forest is valuable to forest villagers and also to forest surrounding villagers.

D. Water Quality of Neora Valley

The water quality in the undisturbed forest area is good. The pH value in disturbed catchment is around neutral value but turns slightly acidic, as it approaches towards the undisturbed and semi-disturbed forest due to presence of humus in the soil. The quantity of TDS and TSS is within the permissible limit in undisturbed and semi disturbed catchment but the quantity increases in semi disturbed and disturbed forest catchment. The BOD and COD is higher than the permissible limit in disturbed forest catchment but minimum in undisturbed forest catchment. The amount of acidity and alkalinity is also lower in undisturbed forest than disturbed forest catchment. The quantity of total coliform and fecal coliform is near around 100 MPN/100ml in disturbed forest catchment. But the amount of total coliform is lower than 1.1 MPN/ml in semi disturbed and undisturbed forest catchment. The fecal coliform is absent in undisturbed and semi-disturbed forest catchment.

E. Soil Quality including Major Forest Species

The soil pH indicates that the soil is acidic in undisturbed and semi disturbed forest. The pH value in disturbed forest catchment is neutral. The water holding capacity (%) and

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moisture content (%) is higher in the undisturbed forest catchment. The proportion of sand in soil texture gradually decreases with the change of forest catchment from disturbed to undisturbed. Table 2 showed that the maximum percentage of carbon content is found to be 47.86% in case Cane species. The amount of carbon sequestration can be estimated by all sampled species in the study area.

TABLE 2. ROLE OF NEORA VALLEY FOREST SPECIES IN MAINTAINING FOREST-WATER-SOIL RELATION

Name of the species	% of Carbon, Hydrogen & Nitrogen of Neora Valley Forest Species		
	Carbon (%)	Hydrogen (%)	Nitrogen (%)
Cane	47.86	4.97	1.89
Rhododendron	46.97	4.85	1.37
Pine	46.98	5.49	1.46

F. *Travel Cost Method*

The disturbed forest catchment, lava is a famous tourist spot. So we conduct a tourist survey to assess the tourism value of the place. Majority of the tourists come in lava from Kolkata and other parts of West Bengal. This involves expenditure for travelling is more than Rs. 2000 per head. Most of the tourists agree to go to Neora valley forest to enjoy the nature. This involves additional Rs.500/ head. That means the value of Neora valley forest is around Rs 2500 per head per visit.

IV. **Conclusion**

The selected catchment of the study areas treatment experiments have shown that streamflow increases as forest cover decreases, and vice versa. The reason for this is that forests evaporate significantly more water than grasslands or crops. Apart from rainfall, the magnitude of the change in annual streamflow is also affected by forest type and slope aspect. Mean annual streamflow can be expected to rise by between by between 10 and 60 mm (but usually 25 and 50 mm) for each 10% of the catchment area cleared of forest, depending on the forest type and rainfall [16]. Conversions to forestland may be the potential to reduce erosion and subsequent sedimentation, as well as reduce levels of dissolved nutrients and pesticides in surface runoff and groundwater. These improvements in water quality may be a function of lower amounts of runoff and leaching as well as lower concentration of potential pollutants that are expected to result from the conversion of forestland. Contingent Valuation Techniques are applied to assess the importance of forest for the villagers who are resided in or nearby the forest fringe areas also Travel Cost Method is applied to estimate the tourism value of the study area.

Acknowledgment

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