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ORIGINAL ARTICLE

Bamboo Based Agro-Forestry Models in India and its Potential for Land Restoration in Uttar Pradesh

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ABSTRACT

The objective of the study is to delineate benefits of bamboo as an intercrop with other agricultural crops. Paper also focus on district wise availability of wasteland and category wise affected land in Uttar Pradesh. Bamboo is an important component for flood prone regions due to its unique properties. It is suggested to cultivate bamboo in the area which is being affected every year due to frequent occurrence of natural calamities. Study is mainly based on data obtained from secondary sources in order to identify existing agro-forestry models in the country and potential of bamboo to restore the flood affected and degraded land.

Key words: *Bamboo, Agro-Forestry Models, Land Restoration*

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INTRODUCTION

Uttar Pradesh is situated in Northern India sharing an international boundary with Nepal. The state is bordered by Rajasthan in west, Haryana and Delhi to northwest, Uttarakhand to north, Bihar to east, and Jharkhand to south east and Madhya Pradesh to south west. This is the most populous state of the country and the fifth largest state. The state is divided into 4 divisions, namely western UP (30 districts), eastern UP (28 districts), Central UP (10 districts), and Bundelkhand (7 districts). At present state have 75 districts, 327 Tehsils, 822 blocks and 107452 revenue villages. Uttar Pradesh state is divided into nine agro-climatic zone (i) Bhabhar and Tarai Zone (ii) Bundelkhand zone (iii) Central zone (iv) Eastern plain zone (v) Mid-western plain zone (vi) North eastern plain zone (vii) South western semi-arid zone (viii) Vindhyan zone and (ix) western zone (Khan & Sharma, 2008). The state can also be divided into three distinct physiographic regions. The Tarai region in the north is highly fertile and has thick forest with rich flora and fauna. Crops like wheat, rice and sugarcane are commonly grown by the farmers. The Gangetic plain at the centre is large as it covers nearly two thirds of the state. The main crop of the region includes paddy, wheat, sugarcane, grams and millets. The eastern tract of this plain is subjected to periodical floods and droughts, while the western and central tracts are comparatively better with a well-developed irrigation system. The Vindhyan hills and plateaus in the south majorly comprise the Bundelkhand division. There are two

main cropping seasons in the state, viz, Rabi and Kharif. The Kharif cropping season is from July to October during the southwest monsoon. Paddy, maize, jowar, bajra, pulses (arhar, black gram, green gram), potato, cotton, groundnut and soyabean are various crops grown in the Kharif season. Rabi cropping season is from October to March, and the important Rabi crops are wheat, barley peas, chickenpea and mustard. Zaid season is between Kharif and Rabi, and the major crops grown during this season include watermelon, muskmelon, cucmber and vegetables. The state produces numerous diverse crop varieties due to its comparative advantage of a wide range of agro-climatic conditions.

AGRO-FORESTRY AS SUSTAINABLE MANAGEMENT OPTION

Agriculture alone is not economical in the long term for the growers due to loss of nutrient and moisture content in soil, frequent attacks of micro-organisms, access use of chemical fertilizers and pesticides, farmers are also not getting high returns due to reduced productivity. Jhum cultivation, which is still prevalent in Northeastern states resulting in gradual shrinkage of land and in unbalanced ecosystem. To decipher this dilemma, there is a need to adopt integrate farming system. Agriculture crops with tree farming and leguminous crops along with forestry species will improve the soil nitrogen content and increase crop yield, high biomass content, high returns and brings ecological stability. Many business corporations and private limited companies has entered into the business such as WIMCO, ITC, West Coast Paper Mills Ltd., Hindustan paper Mills Ltd., IFFCO initiated agro-foretry activities by associating with large farmers. A government report in its study stated that (NRCAF, 2007) says there is a tremendous scope for employment generation by improved agro-forestry practices by generating employment for 943 million person days annually in 25.4 Mha of agroforestry area.

BENEFITS OF AGRO-FORESTRY

Agro-forestry is of great importance because of meeting diversified needs of the people and also by generating income. It has helped in meeting half of the demand of fuel wood, 2/3 of the small timber, 70-80 percent of plywood, 60 percent of raw material for pulp and paper and 9-11 percent of the green fodder requirement for livestock besides increasing the shade cover for under growth plants which helps in retaining soil moisture and reducing evapo-transpiration, protect soil from erosion. Soil acidity or rate of acidification may be reduced through bases in litters of the tree component of agro-forestry system. There may also be a reduction of soil toxicities, salinity and sodicity by trees in association with other management measures. Incorporation of fodder grasses and trees in the agro-forestry model facilitate in enhancing the dairy products by ensuring a continuous supply of green fodder to cattles. Bamboo has emerged as a major substitute for timber and other wood products, for which bamboo has tremendous scope in agro-forestry practices.

STATUS OF AGRO-FORESTRY IN UTTAR PRADESH

India is the first country in the world to adopt the national Agro-forestry policy in 2014, under Ministry of Agriculture and farmer's welfare with the objective to expand tree plantation in combination with crops and other livestock to improve overall productivity, reducing unemployment, generating additional sources of income and livelihood support to small landholders. The policy also highlights that agro-forestry could be implemented to meet the domestic and industrial requirements of the country for timber, fuel wood and other products. Uttar Pradesh is one of the state contributing to the national food grains stock of India. Agriculture is the backbone of the state's economy and about 74% of rural households are dependent on agriculture for their income and livelihood support. Farming sector is playing a significant role in improving the socio-economic and environmental conditions of the state (NRCAF, 2007).

Western Uttar Pradesh has well developed agro-forestry models due to wood based industries, which have been promoting tree based agro-forestry farming system to meet their demands of raw material (Dwivedi, *et al*. 2007). The farmers of this region are accepting and adopting industrial agro-forestry models and raising eucalyptus, poplar and bamboo for commercial cultivation of trees on farmlands with agricultural crops helped in income generation (Scherr 2004). Traditional agro-forestry system is retained by the farmers in the state for domestic purposes. *Azadirachta indica*, *Dalbergia sisoo*, *Acacia nilotica* and *Eucalyptus spp* are few dominant species of the state. High demand of wood as raw material for various wood-based industries creates opportunities for enterprising farmers and planters. There is a need to establish agro-forestry pulpwood plantations to meet the growing needs of the industries in addition to satisfying domestic demands of the farmers (Dwivedi, *et al.* 2007)

Uttar Pradesh state government has given continuous emphasis on large scale plantation through various schemes like MGNREGA, Rashtriya Krishi Vikas Yojna, National Horticulture Mission, National Bamboo Mission, special plantation drives and also through various private companies who has been promoting plantations on private land on a large scale. Plants such as *Ficus infectoria, Tamarindus indica, Ficus religiosa, Ficus bengalensis, Holoptelia integrifolia, Ficus locar, Terminalia arjuna* and *Delbergia sisoo* are major tree species planted. In agro-forestry models, underground root competition for moisture, nutrients and space are relatively more important factors in agro-forestry systems than in above ground competition. The production of bamboo can be assessed by the number of new culms produced annually. The production of new culms is mostly dependent on the degree of congestion, clump age, rainfall of the previous year and the nature of completion.

BAMBOO AS AN INTERCROP

Bamboo based agro-forestry model plays important role in enhancing productivity, sustainability and resource conservation. It has many advantages over trees such as, relatively short time span from planting to harvest as it requires four to five years to yield first harvest, if grown offsets, which is much earlier than any other woods species. It raised from seedlings, first harvest is obtained after seven years and this initial period can be sustainably utilized for raising intercrops and enhancing the income of the farmers.

Under agro-forestry system, bamboos are benefited due to sharing of resources like irrigation, fertilizers, weeding, etc. with intercrops, as a result of which the quantity and quality of bamboo species are expected to be much higher as compared to monoculture or unmanaged plantations. The purpose of agro-forestry plantations is to improve socio-economic conditions and ecological considerations which could be done by monoculture plantations, wind breaks, riparian filter, permaculture etc which also plays significant role in enhancing productivity and also the conservation of natural resources.

Various agricultural crops have been found successful like tomato, watermelon, sweet potato, ginger and turmeric and few medicinal plants. Among those ginger and turmeric are shade tolerant plants which can be taken up even after forming partial canopy. Some of the shrubby medicinal plants can also be introduced as an under crop in bamboo plantation. In north eastern states, some of the crops being cultivated with soya bean and maize and nitrogen fixing leguminous plants were recommended to improve the availability of nitrogen.

Inter-crop plants help in recycling and retaining the nutrients in the soil and prevent growth of weeds. The duration of intercropping depends on the spacing provided in bamboo plantations. As soon as the canopy closes, the shade prevents the growth and development of many crops. Pruning of culms could be considered to improve the light penetration therefore permit sustainability of intercrop for longer period and hence improve the profitability of the farmers.

Table 1: Successful Agro-forestry Models across the state with their productivity

Agro-forestry crops	Regions	Productivity
Wheat crop with boundary plantation of Poplar	Baghpat district	Litter production averaged 1.103 t ha–1 in 3- and 4-year-old plantations. No adverse effect was noticed on wheat with poplar
Casuarina with turmeric	Eastern UP	The fresh rhizome yield for turmeric was 8.6 t ha–1, which was higher than the yield (7.6 t ha–1) obtained in open area
Paddy/ wheat with *Eucalyptus tereticornis*	Faizabad	Paddy grain yield was found to be 14.7–19.7% less under agroforestry system and wheat yield grain was 26.4–34.6% lower than open cultivation
Eucalyptus based agro-forestry system	Sahranpur	Biomass productivity varied from 13.6 t/ha for 6-year-old to 33.81 t/ha for 10-year-old plantations
Poplar based agri-silviculture system	Saharanpur	Estimated timber biomass of poplar at the age of 3 years was 0.126 t tree–1, which became 0.267 t tree–1 at the age of 7 years
Lemon grass with Poplar plantation	Allahabad	Herbage yield (48.5 t/ha) and oil yield (0.197 t/ ha–1) of lemon grass under poplar trees.
Eucalyptus with aromatic grasses	Rampur	Higher herbage and oil yield was recorded in pure fields of aromatic grass than the intercrops grown under eucalyptus hybrid stands. Maximum oil yield was produced by lemon grass and minimum by palmarosa. Higher quantity of litter was produced in palmarosa than in citronella

BAMBOO BASED EXISTING AGRO-FORESTRY MODELS IN INDIA

In this section, various agro-forestry models were discussed based on literature review to demonstrate comparison analysis of bamboo as a subsidiary crop with other agricultural crops being practiced across the country. A study conducted by G.B Pant University of Agriculture and Technology, Pantnagar, cowpea was intercropped with eight different bamboo species. In the initial two years, the height attained by *Bambusa balcooa* is 12.5 m followed by *Dendrocalamus hamiltonii*. However, yield of cowpea were affected when planted with *Dendrocalamus hamiltonii* in both the years due to the fast growth of this species as compared to others. Among all eight bamboo species, maximum height has been attained by cow pea with *Dendrocalamus asper* followed by *Balcooa tulda*. In another study conducted by G.B Pant, Pantnagar, *Dendrocalamus asper* were intercropped with soyabean. Results revealed that soyabean grown well as an intercrop for first three years. The successful intercropping of soyabean with *Dendrocalamus asper* is due to slow growth of *Dendrocalamus asper*. In Sonitpur district of Assam, different intercrops, viz, mustard, seasame, ginger, soya bean, French bean, papaya, banana, pigeon pea, tea, citronella, vertiver and lemon grass were evaluated with different bamboo species, viz., *Bambusa balcooa, Bambusa nutans, Bambusa tulda* and *Dendrocalamus hamiltonii*. Yield performance of the intercrops revealed that there was significant decrease the average yield of all intercrops in last three years. The reduction was comparatively less in ginger, turmeric, tea and lemon grass whereas the first year results indicated that all crops including field and horticulture crops can be successfully grown without any significant difference from the control (Jha and Lalnunmawia 2004). Bamboo based agro-forestry system has been tried for red and laterite zone of West Bengal involving two bamboo species (*Bambusa balcooa* and *Bambusa tulda*). Results revealed that agricultural crops like paddy, groundnut, cowpea, okra, bottle gourd, pigeon pea, turmeric, elephant foot yam and colocasia were found to be successfully grown as intercrops. Growth attributes of bamboo plants, irrespective of species and spacing were significantly higher when grown with intercrops than pure plantation. No significant difference was observed when planted at closer and wider spacing. Further, it was suggested that wider spacing between two bamboo crops results in better utilization of light, space, moisture and nutrients

(Dwivedi, *et al*. 2007). In a study conducted by Bharathiar University, Coimbatore, in which intercropping of four crops i.e. pigeon pea, soyabean, turmeric and ginger was done to compare the growth and yield of four crops intercropped with *Bambusa bambus*. Four model plots were developed with all four crops.

Table 2: Intercropping of bamboo with other agricultural crops

Model plot	Pure agricultural crops yield (kg/ha)	Pure bamboo yield (kg/ha)	Agricultural crop yield (kg/ha)	Bamboo yield (kg/ha)
			Intercropping	
Bamboo/pigeon	700	38,250	600	13,750
Bamboo/soyabean	1,700	36,230	1,400	14,350
Bamboo/turmeric	6,050	24,750	4,300	12,000
Bamboo/ginger	1,000	29,750	650	15,750

Ginger is a shade loving plant and can be grown with wide variety of tree species. In the above study when ginger grown as pure crop it shows high productivity when compared to mixed crop. In table 2, pigeon pea is showing a productivity of 700 ka/ha when grown as a pure crop whereas productivity reduce by 100 kg/ha when planted with bamboo as an intercrop. On the other hand, soyabean may grow under varying climatic conditions either as a pure crop or as an intercrop, the productivity of soya bean as pure crops was 1700 kg/ha which has reduced to 300 kg/ha, when planted as an intercrop with bamboo species. Turmeric is a shade loving plant and can be grown in association with variety of other trees. All agricultural crops were grown as a subsidiary crop and bamboo was a main crop. Both bamboo and agricultural crops were showing average productivity neither facing a loss nor very high value. By adopting this system, farmers will gain returns from two different varieties of crops which will vary with the existing price of the crop (Scherr, 2004).

WASTELAND AVAILABILITY IN THE STATE

Due to increase in population pressure, there is an excessive demand for land and land-based products for agricultural as well as non-agricultural purpose. In India, this widening gap had led to over utilization of land resources regardless of their potential and limitations, resulting in the creation of vast stretches of wastelands affected by soil salinity, water logging, desertification, soil erosion etc., and thus resulting in progressive decrease in per capita cultivable land.

District wise wasteland data has been prepared by Department of Land Resources under Ministry of Rural development in 2011. If we look at the overall image on the wasteland status, it shows that there is a marked decrease of about 1,269 sq km been recorded during the study period. Major reductions were recorded in 'gullied land' waterlogged and salt affected categories. Most of the areas from these classes were observed to be converted into cropland and water bodies. Affected land in the state under various category

AFFECTED LAND IN THE STATE UNDER VARIOUS CATEGORY

Table 3 below shows, area covered under 5 different classes and number of districts affected under respective categories. Majority of the districts i.e. 68 districts were categorizedin 'Land under open or dense scrub' category covering an area of 2,914 sq km which is being affected and where the vegetation is dominated by shrubs also include grasses and herbs. It may occur naturally or may be the result of excessive pressure on the land. Waterlogged or marshy land refers to the saturation of soil, it blocks off the water and prevent air getting into it. In such condition air phase is restricted and anaerobic conditions prevail. It also results in reduction of iron and manganese oxides in

the soil. In UP, total 8,65 sq km of the area in 61 districts are affected by water logging which may be permanent or seasonal. Out of 75 districts in UP, 51 of them covering an area of 2,553 sq km is affected by salinity/alkalinity. Salinity caused due to accumulation of soluble salts and low exchangeable sodium. The pH value usually ranges less than 8.5 whereas the pH value in alkaline soils ranges from 8.5 to 10 with major accumulation of alkali salts. Poor drainage, rapid evaporation of alkaline soil solution and excess uptake of alkaline salts and little peculation are the major factors causing soil alkalinity.

Table 3: Affected districts under various categories

Category	Area covered (in sq km)	No of districts affected	Districts affected
Gullied or ravenous land	1198.58	35	Agra, Allahabad, Ambedkarnagar, Auriya, Azamgarh, Badaun, Banda, Barabanki, Basti, Bulandshahr, Chitrakoot, Etawah, Faizabad, Gautambudhdha nagar, Hamirpur, Hardoi, Jalaun, Jhansi, Jyoti phule nagar, Kanpur rural, Kaushambi, Lucknow, Hathras, Mahoba, Mathura, Mau, Mirzapur, Pratapgarh, raebareli, Sant Kabirnagar, Sant Ravidasnagar, Sitapur, Sultanpur, Varanasi
Land with dense or open scrub	2914.5	68	Agra, Aligarh, Allahabad, Ambedkar nagar, Azamgarh, Badaun, Baghpat, Ballia, Balrampur, Banda, Barabanki, Bareilly, Basti, Bahraich, Bijnor, Bulandshahr, Chandauli, Chitrakoot, Deoria, Etah, Etawah, faizabad, Farrukhabad, Fatehpur, Firozabad, Ghaziabad, Gazipur, Gonda, Gorakhpur, Gautambuddha nagar, hamirpur, Hardoi, Jalaun, Jhansi, Jyoti phule nagar, Kannuaj, Kanpur rural, Kanpur urban, Kasganj, Kaushambi, Kushunagar, Lakhimpur kheri, Lalitpur, Lucknow, Hathras, mahoba, Mainpuri, Mathura, Mau, Meerut, Mirzapur, Moradabad, Muzaffarnagar, Pilibhit, Pratapgarh, raebareli, Rampur, Saharanpur, Sant kabirnagar, Sant ravidasnagar, Shahjanahanpur, Shrawasti, Siddarthnagar, Sitapur, Sonbhadra, Sultabpur, Unnao, Varanasi
Waterlogged and Marshy land (Permanent/ Seasonal)	865.73	61	Agra, Aligarh, Allahabad, Ambedkarnagar, Auriaya, Azamgarh, Budaun, Ballia, Balrampur, Barabanki, Bareilly, Basti, Bahraich, Bijnor, Bulandshahr, Chanduali, Deoria, Etah, Etawah, Faizabad, Farrukhabad, Fatehpur, Firozabad, Ghaziabad, Ghazipur, Gonda, Gorakhpur, Gautambuddha nagar, Hardoi, Jaunpur, Jyotiba phule nagar, Kannuaj, Kanpur rural, Kanpur urban, Kasganj, Kaushambi, Kushinagar, Lakhimpur kheri, Lucknow, Hathras, Maharajganj, Mahoba, Mainpuri, Mathura, mau, Meerut, Mirzapur, Pilibhit, Pratapgarh, Raebarelli, Rampur, Sant Kabrinagar, Sant ravidasnagar, Shahjahanpur, Shrawasti, Siddarthnagar, Sitapur, Sonbhadra, Sultanpur, Unnao, Varanasi
Land affected by salinity/alkalinity	2553.18	51	Agra, Aligarh, Allahabd, Ambedkarnagar, Auriya, Azamgarh, Budaun, Ballia, Barabanki, Bareilly, Basti, Bahraich, Bulandhsahr, Chanduali, Etah, Etawah, Faizabad, Farrukhabad, Fatehpur, Firozabad, Ghaziabad, Ghazipur, Gorakhpur, Gautambuddhanagar, Hamirpur, Hardoi, Jalaun, Jyoti phule nagar, Kannauj, Kanpur rural, Kanpur urban, Kasganj, Kaushambi, Kushinagar, Lakhimpur kheri, Lucknow, Hathras, Mainpuri, Mathura, Mau, Mirzapur, Pilibhit, Pratapgarh, raebareli, Rampur, Sant Ravidasnagar, Shahjahanpur, Sitapur, Sultanpur, Unnao, Varanasi
Degraded pastures/ grazing land/ under plantation crop	21.81		Agra, Banda, Bahraich, Bijnor, Bulandshahr, Chandauli, Gorakhpur, Lucknow, Mathura, Shrawasti, Sonbhadra,

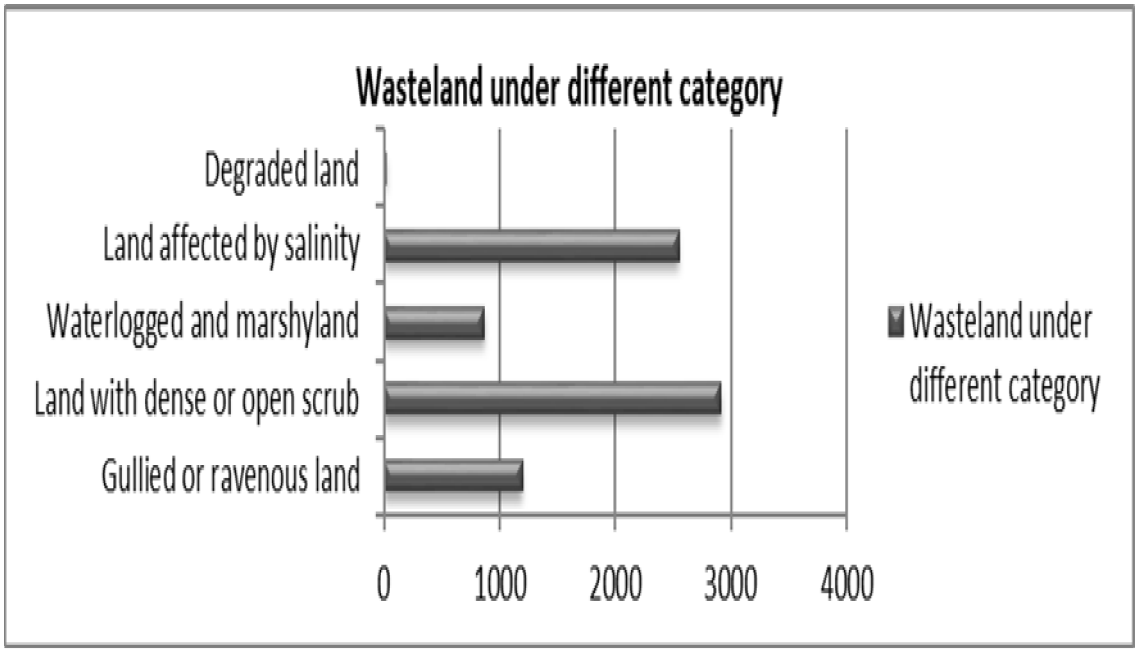

Fig. 1: Wasteland availability under different categories

According to the government data for the year 2001, around 7,553.8 sq km of land area which cover 68 districts in the state, is under wasteland or degraded land, under 5 main categories i.e. degraded land, land affected by salinity, waterlogged and marshy land, and land with dense or open scrub and gullied or ravenous land categories. Bamboo has an ability to adapt under various environmental conditions due to its nutrient and water conservation nature which enables them to grow in hard adverse situations and best suited for eco-restoration purpose. Bamboos are known to grow in "poor soils" and therefore used for rehabilitation of degraded lands. Bamboo has a potential to grow well on degraded soils and steep slopes where many plants difficult to grow. Bamboo has an extensive fibrous root system that makes it capable of stabilizing and holding the soil and preventing soil erosion. Bamboo can grow upto 1 meter in a day and due to its extensive root system, it forms rich vegetation and restore productivity of bare land over a short period of time.

FLOOD PRONE DISTRICTS IN UTTAR PRADESH

Floods are the most common occurring in the state, affected millions of people every year. Important rivers which create floods in the state are Ganga, the Yamuna, the Ramganaga, The Gomati, the Shadra, the Ghagra, the Rapti, and the Gandak. Out of the 240.93 lakhs hectares of geographical area of the state about 73.06 lakh hectares is flood prone. And the estimated loss to crops, house and livestock is to Rs 432 crore annually. Overall impact of flood disaster is beyond any limit which includes loss of human life and livestock, destruction of crops, sedimentation and silting on inhabited land, loss of stored grains, loss of feed and fodder, loss of livelihoods, shelter destruction, adverse impact of health, education, drinking water and sanitation. According to the government report, around 610 villages which were occupied by 3,51,936 population and covering an area of 50,343 ha were affected in Gorakhpur district in the year 2007. Eastern UP districts are mainly known for occurrence of flood every year because of its geographical location which has devastating effect on farming communities and hampering the socio and economic lives of the people and making poor farmers more vulnerable. There is urgent need to develop diverse and intensify farming practice by increasing crop rotation and crop frequency with the time and space management technique.

SUITABILITY OF BAMBOO IN FLOOD PRONE AREAS

Bamboo is planted particularly along rivers, streams and water bodies for soil stabilization and erosion control because of its extensive root system. It also increases the interception of rain and prevents runoff and soil erosion. Silting up of tanks, lakes and reservoirs can be successfully done through bamboo plantation along the streams flowing into them. River bank stabilization can be done by planting bamboo specie such as *Ochlandra scriptoria* and *Bambusa multiplex*. Other species includes *Bambusa vulgaris, Melocanna baccifera* are best suitable for plantation to control soil erosion on the river bank. In a study, conducted in 2013 by Kasetsart University, Thailand, in which survey was taken to identify potential bamboo species that could tolerate flooding situation for longer period. 10 bamboo species were found to be survived and tolerated to flood stress. Out of 10 species, *Bambusa bamboos, Bambusa blumena* and *Bambusa beecheyana* were found to be more tolerant than others.

Table 4: Flood affected districts

Districts	Blocks
Azamgarh	Haraiya
Bahraich	Balha, Kaiserganj, Mahsi, Mihipurwa
Gorakhpur	Bansgaon, Barhalganj
Maharajganj	Dhani
Shravasti	Ikauna
Sidharthnagar	Naughat, Uska bazaar, Barhani bazaar, Birdpur, jogiyakhas

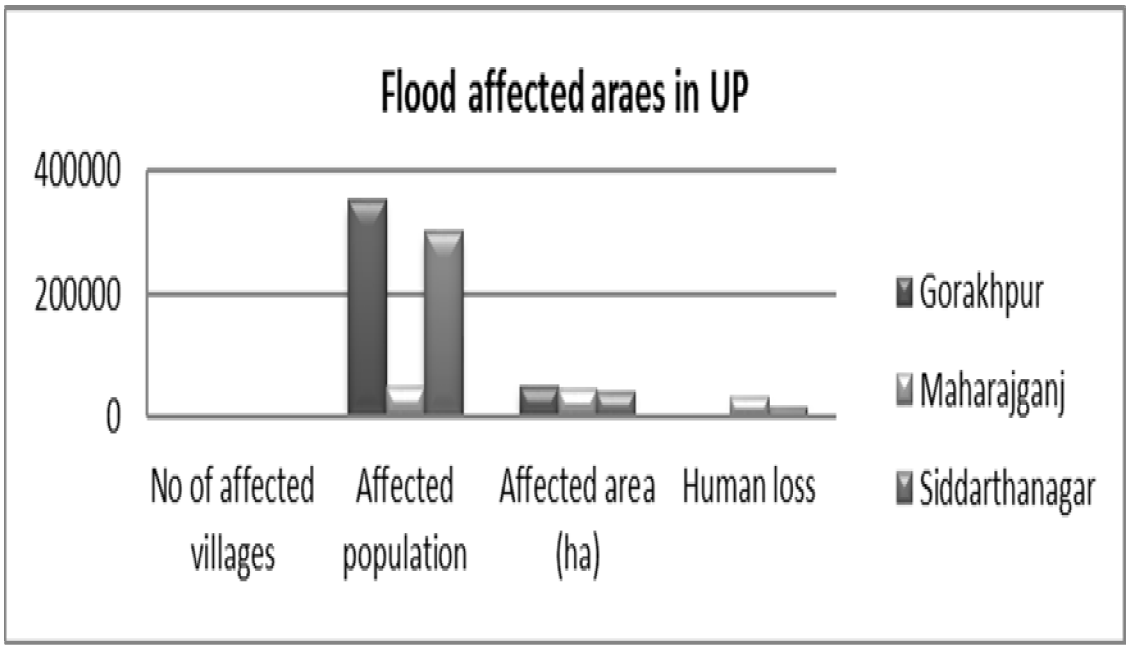

Fig. 2: Flood affected areas in state

BAMBOO SUITABILITY IN RAVINES AND GULLEYS

Ravines form small, medium, deep and narrow gulleys constituting 1198.58 sq km in 35 districts of the state. Ravenous land causes serious degradation by soil erosion and resulting in loss of vegetative cover which also have serious impact on the productivity of the adjacent land. Therefore, there is a need take action for the rehabilitation of the land. Rehabilitation of the area through forming a vegetative cover rather than going for engineering measures as it will be cost effective. In ravine areas plantation of

Dendrocalamus strictus has been suitable with a spacing of 4 x 4 m and 400 plants/ha is ideal and various trenching and water conservation measures.

BAMBOO AND ITS ROLE IN MAINTAINING THE SOIL HEALTH

Bamboo helps in maintaining the physical, chemical and biological properties of soil due to its high biomass accumulation and having tendency of abundant litter fall. Bamboo also have high silica, rich litter production of leaves and twigs which slowly decomposes returning substantial amount of N, K, Mg, Ca and P. The high fine root content helps in recovering most of the nutrients leached deeper in the soil profile. Improvement in the physical properties is reflected through bulk density, lower surface resistance to penetration, increased porosity, higher rain water infiltration and high rate of aggregate stability. Canopy shade of the plant also plays role in altering the soil conditions to improve to the microbial activity and the rate of soil mineralization (Arunachalam & Arunachalam, 2000) The ability of bamboo to grow in wide variety of soil, from marginal to semi-arid, which makes them perfect for soil rehabilitation and plantation of *Dendrocalamus strictus* has an efficient restoration potential and ability to rehabilitate soiled land in mining site in dry tropical regions of India.

CONCLUSION

Bamboo based agroforestry models are encouraged as a sustainable approach towards food and ecological security and to achieve Sustainable Development Goals. Potential of bamboo for restoration of degraded land and its potential to store rich nutrient and retain water makes it best suited to restore the degraded land and flood prone areas. Due to its interconnected root system, bamboo species plays an important role in maintaining the soil health, increased productivity and preventing soil erosion. In order to arrest frequent flood and draught occurrence and to bring the wastelands back to their productive capabilities there is a need to adopt appropriate and innovative technologies need to be planned on scientific basis. By incorporating bamboo into mixed use agroforestry components, we could enhance the productivity by integrating it with other agricultural crops on farmlands, homesteads and farm boundaries etc.

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