VALUATION OF ECOSYSTEM SERVICES FROM PLANTED FORESTS: PREVENTION OF WIND EROSION- A CASE STUDY FROM HARYANA, INDIA

N.S. BISHT*, M.S. GUSAIN**, C.J. SINGH*** AND A.K. HOODA****

Introduction

The Indian hot arid zone is characterized by water deficit all across the year. It occupies approximately 0.32 million km^2 area, mainly in Gujarat, Haryana, Punjab and Rajasthan, while scattered pockets of hot aridity are also available in Andhra Pradesh, Karnataka, Maharashtra and Tamil Nadu. More than 70 per cent of the hot arid zone is occupied by mobile sand dunes, desert and grey brown desert soils, which are most vulnerable to wind erosion. The wind velocity in the region generally varies between 10-15 km/hr which peaks upto 27 km/hr during summer (Ramakrishna *et al.*, 1990). Strong wind regime, highly erodible soil and scattered vegetal cover characterize the region by massive wind erosion and sand drifts. The sand drifts too often result in encroaching human settlements, blockade of highways, railways and chocking of irrigation channels. During summer (March- June), the soil erosion is massive owing to ordinarily high south- west wind regime (Dhir and Venkateswarlu, 1996). A sandy field looses 1.19 t/ha/day soil at 30 km/hr wind velocity; whereas it is only 0.23 t/ha/day for loamy sand (Gupta, 1983). A bare sandy soil dune experiences loss of as much as 37 cm surface soil (1,449 t/ha) during April to June (19.32 t/ha/day soil loss) compared to a soil loss of 0.29 t/ha/day in an arable field with pearl millet (*Pennisetum typhoides*) stubbles of the previous season crop, and hardly any soil loss from a well vegetated dune (Gupta, 1983). In agrarian system, the soil loss is double in case of ploughed land, compared to un-ploughed, and worst for deep ploughed by tractor (Dhir and Venkateswarlu, 1996).

Pearl millet is the main crop grown by the people. Besides this, cattle rearing (goat and sheep) is the predominant socio-economic activity in this region. Farmers protect and manage the agrarian land through crop residues and live fences during critical periods. Cultivation of dune slopes is the major landuse in areas receiving more than 150 mm rainfall annually. Since the first five-year plan (1950-51 to 1955-1956), government has sponsored two major activities viz., sand dune stabilization and shelter-belt plantations under wind erosion control programme for this region.

Alternatives for vegetal control of mobile sand dunes with planting of trees, shrubs and grasses have been studied (Faroda, 1998). Plantations of 13m wide tree belt with trees grown in pits and interspersed with 60m wide grass belt across the wind, provided the best economic results. Shelterbelts along the crop field boundaries reduce injury to tender seedlings of crop species from sand blast and hot desiccating winds. Usually, a three-row windbreak of *Acacia tortilis, Cassia siamea* and *Prosopis juliflora* as side rows and *Albizzia lebbek* as central row is preferred. At least 14 per cent higher soil moisture and 70 per cent improvement in grain yield for pearl millet was reported in the leeward side, compared to a crop field devoid of shelterbelt (Gupta *et al.*, 1997). An increase in yield of lady's finger (*Abelmoschus esculentus*) by 41% and cowpea (*Vigna unguiculata*) by 21% on the leeward side of a micro-shelter belt of tall and fast growing cash crop like cluster bean (*Cyamopsis tetragonoloba*) on the windward side was also reported (Venkateswarlu and Kar, 1996).

A number of studies on intangible benefits using various valuation techniques have been conducted for Indian forests. Chopra and Kadekodi (1997) studied the ecological functions of Yamuna River basin using Contingent Valuation Method (CVM) and estimated an annual value of Rs. 624/ha/yr as the intangible benefits of forest. In another study, Murthy and Menkhuas (1994) estimated recreational value of Keoladeo National Park at ₹ 20,944/ha by using CVM. Hadker *et al.*, (1997) estimated the recreational value and other benefits of Borivili National Park by using CVM at ₹ 23,300/ha. Kumar (2001) estimated the soil conservation value of forests in Doon Valley at ₹ 21,583/ha. However, valuation of government sponsored wind erosion control measures has not been taken so far. The present study was therefore, carried out to estimate the economic value of the regulation functions of the planted forests related to the prevention of damage caused by wind erosion in selected villages of Haryana, where it caused acute damage to the agricultural crops of the region.

* Chief Conservator of Forests (Planning and Development), Mizoram Forest Department, Aizawl.
** State Medicinal Plant Board, Uttarakhand, Dehradun.
*** Technical Officer, Ministry of Environment and Forests, C.G.O. Complex, Lodhi Road, New Delhi.
**** Conservator of Forests, Haryana Forest Department.

Table 1

Profile of the villages covered during the study

Village	Kairu	Devrala	Nimriwali
Block	Tosham	Tosham	Bhiwani
Area (ha)	3,974	2,022	200
Non-arable land (ha)	510	297.6	19.2
Arable land (ha)	3,464	1,724.8	160
Plantation (ha)	350	24	21
Number of household	1,349	878	461
Household size	6	6	6
Population	8,077	5,387	2,599
Male	4,355	2,895	1,386
Female	3,722	2,492	1,213
No. of female per 1000 male	855	861	875
Scheduled Caste population	2,068 (25.60%)	848 (15.70%)	402 (15.50%)
Literate	4,278 (63.70%)	3,004 (66.70%)	1,527 (68.40%)
Workers	2,380	2,343	1,114
Cultivators	1,186	1,556	551
Agricultural labourers	337	436	260

Study Area

The study was conducted in Haryana, where desert conditions prevail in south and south western region, covering about 1.4 million ha land area. Sand dunes are very active in this region. During peak summer, storms of velocity as high as 60km/h are common, resulting into heavy transport of sand particles causing damage to adjacent agriculture, communication lines and irrigation channels. Forests occupy only 3.43 per cent of the total land area (44,212 km^2) of the state (FSI, 2009). Plantations of tree species as wind breaks and shelterbelts viz., *Acacia tortilis, A. senegal, Albizzia lebbek, Ailanthus excelsa, Dalbergia sissoo, Eucalyptus* spp. *Prosopis cineraria, P. juliflora* and *Tecomella undulata* with grasses like *Cenchrus ciliaris, C. setigerus, Lasiurus sindicus* and *Saccharum munja* were started as early as in 1980 under social forestry programme by the State Forest Department. The agroforestry system practiced in the region include *Acacia nilotica, Prosopis cineraria, Zizyphus mauritiana, Salvadora oleoides, Tecomella undulata* as overstorey trees, with the arable crops like *Brassica compestris, Triticum aestivum, Cicer arietinum, Gossypium hirsutum, Pennisetum typhoides* and *Vigna radiata*.

Three villages, viz., Kairu, Devrala and Nimriwali in Bhiwani district of Haryana located at 28°19' to 29°5' N latitude and 75°26' to 75°28' E longitude were selected for valuation of regulation function of the plantations with respect to mitigating the impact of wind erosion. The district is surrounded by Hissar on the north, part of Jhunjunu and Churu districts of adjacent arid and semi arid areas of Rajasthan in the west, Mahendragarh and Jhunjunu on its south and Rohtak in the east. The northern part of the district is occupied by alluvial plains, while the southern region has remnants of Aravali mountainous range with semi-desert conditions. Ambient temperature ranges from 2°C to 45°C. Rainfall in scanty (average 400 mm/yr), most of it falls during July-August. Soil is loam (northern region) to sandy (southern region). The ground water is saline prominently due to lack of any drainage system, the level of which is decreasing rapidly. Instances of sand dune movement in the recent past were common in the district. *Acacia tortilis, A. catechu, Azadirachta indica, Dalbergia sissoo, Ficus religiosa* and *Prosopis cineraria* are the predominant natural tree species of the region. *Pennisetum typhoides* and *Gossypium hirsutum* during summer, and *Triticum aestivum* and *Brassica compestsis* during winter, are the main agriculture crops in the selected villages. A brief socio-economic profile of these villages is presented in Table 1.

Material and Methods

The methodology of Sheil *et al.* (2002) was followed to assess the perception of people for regulation services generated by different landscape units. It included community meetings, household survey and Pebble Distribution Method (PDM) exercise. An informal interaction was carried out with the villagers during the community meetings. The objectives of the study were explained to them, different parameters of the questionnaire were discussed, and it was modified accordingly. This

exercise was conducted within a mixed group of villagers. Pebbles were assigned by the people to different predetermined attributes. The discussion that was held amongst the villagers regarding the distribution of pebbles to various landscape units was recorded and valuable conclusions were drawn.

Data were collected about their resources, landscape units, environmental issues and activities/ program going on in their villages. Households were selected on the basis of land holdings, literacy, occupation and caste. Contingent Valuation Method (CVM) was used to assess their willingness to pay (WTP) for raising plantations and its maintenance for mitigating the impact of wind erosion. 180 questionnaires (approx. 10% of the household) were filled during the field work and these were used for stepwise regression analysis treating WTP as dependent variable and rest of the parameters like income, land holdings, household size, education status, cattle units, awareness of environment issues, etc. as independent variables. People were also asked to express their WTP in a scenario where their income increased due to protection of agriculture crop by the plantations.

The present study is based on the assumption that plantations that have been raised on community lands are serving a good purpose in mitigating the impact of wind erosion. This is directly related to the agricultural productivity, soil and water conservation and other intangible benefits such as clean air and local climate regulation. Local people do understand clearly the regulation functions of these plantations and were therefore willing to pay for their maintenance and protection. Therefore, this value can be assumed as the value of the regulation services that plantations are providing to these communities to mitigate the impacts of wind erosion.

Results and Discussion

Data obtained from 180 questionnaires were utilized for regression analysis treating WTP as dependent variable and rest of the quantitative and qualitative parameters as independent variables. The model obtained is mentioned below:

WTP= -319.15 - 12.78 HH size + 4.35 Age + 58.06 Edu + 0.005 Income + 30.28 Agri. Land + 15.69 ACU + 86.88 Env.awr

(R^2 = 0.34)

Where:

WTP	-	Willingness to pay
Age	-	Age of respondent
Income	-	Income of the household
ACU	-	Adult cattle unit available with the household
Env.awr	-	Knowledge of Environmental issues
HH size	-	Household size of the respondent
Edu.	-	Education status of respondent
Agri. Land	-	Available agriculture land of household

The regression equation explained the variation in the willingness to pay for the maintenance and protection of plantations. Seven variables, viz. household size, age, education status, income, land holding, number of adult cattle available and knowledge of environmental issues contributed towards the variation in the willingness to pay and 34 % of the variations is explained by these variables. The mean WTP was ₹ 448.00, the maximum WTP was ₹ 2,400.00, while 31 respondents were not willing to pay anything in terms of money. By extrapolating the value of mean WTP to the total number of households in the plantation area, an amount of ₹ 1.20 million was obtained or ₹ 3,048/ha./yr. This was the amount, the people of Kairu, Devrala and Nimriwali villages were willing to pay for the maintenance of 395 ha. of plantations in and around their villages. It can be assumed as the value of regulation function of the planted forests associated with the prevention of wind erosion.

The mean WTP of the respondents to different variables is mentioned in Table 2 (a to f). It was observed that the mean WTP increased with the increase in annual income. Among all variables studied, the maximum mean WTP (₹ 985.71) was observed in this category only. It may or may not be related to other variables such as size of land holding, education status, etc. The second most important factor was the size of land holding. Here, mean WTP varied from ₹ 237.00 to ₹ 894.00 per year. It was because agriculture is the main source of income generation for the people of the region and people were aware of the fact that plantations mitigate the impact of wind damage on agriculture production. Large farmers were willing to pay more amount for the maintenance of plantations. Other variables viz. number of cattle, household size and awareness to environmental issues also exhibited the same pattern except the literacy wherein it was noticed that the most educated people (post graduate and above) were willing to pay less amount as compared to the graduates and below graduate category. It was because most of them were not permanently residing in the villages, therefore, not much interested in paying excess money for these issues.

In another scenario, villagers were asked to reveal their willing to pay, in case their agriculture income increased by ₹ 5000.00 per year assuming the positive impacts of plantations on their crops. The village wise detail of willingness to pay is mentioned in Table 3. Most of the people, in the selected villages,

Table 2

Mean WTP under different categories

a. Income (₹/Yr)

Income c ategory (₹ Per annum)	Count	Range (₹)	Mean WTP (₹)
<10000	23	480	122.61
10001-30000	63	1200	200.95
30001-50000	34	2400	506.47
50001-100000	39	2400	697.85
>100000	21	2400	985.71

b. Land holding (Acre)

Land Holding (acre)	Count	Range (₹)	Mean WTP (₹)
0	40	2400	237.00
0.01-2	62	2400	333.87
2.01-5	45	2400	464.80
>5.01	33	2400	894.55

c. Household size

No. of persons	Count	Range (₹)	Mean WTP (₹)
<5	72	2400	342.50
6—10	83	2400	505.74
>10	25	2400	559.20

d. Awareness of environmental issues

Category	Count	Range (₹)	Mean WTP (₹)
Poor	58	2400	300.00
Good	87	2400	451.45
Very good	35	2400	684.00

e. Adult Cattle Unit (ACU)

Number of ACU	Count	Range (₹)	Mean WTP (₹)
0	34	2400	303.53
0.1-2	51	2400	411.77
2.1-5	69	2400	461.39
>5.1	26	2400	625.38

f. Education status

Category	Count	Range (₹)	Mean WTP (₹)
Illiterate	43	2400	286.05
1^{st} - 5^{th}	24	2400	312.50
6^{th} - 10^{th}	67	2400	463.88
11^{th} -12^{th}	29	2400	655.04
Graduate	10	1080	708.00
Above PG	7	1800	522.86

were willing to pay around ₹ 250.00 per year of the additional income. As most of them belonged to the low-income group, they preferred to increase their assets instead of giving it for the maintenance of plantation. However, in Kairu 30.51% of the respondents were willing to pay more than (₹ 1000.00) of their extra income for the maintenance of plantations. Most of these farmers were having large land holdings. The percentage of people which were not willing to pay anything, varied from 15.87% to 18.64%. The reason being that they had limited source of income and were not in a position to pay in terms of money.

In yet another scenario, locals were asked to reveal their willingness to work (WTW) as volunteer for the maintenance of plantations. The villagers who were willing to volunteer suggested their value in terms of mandays. They were willing to spare approximately 2 hrs in a day for about 4-5 days in a week (Table 4).

There was a high per cent of locals who were willing to volunteer themselves for works like serving There was a high per cent of locals who were willing to volunteer themselves for works like serving as guards, carrying out plantation, removing weeds, etc. However, 6.60 % of the respondents were not willing to volunteer themselves to plantation. The reason was that either they couldn't take out time as they were the only bread earners of their family or they thought it is the duty of the government. The number of villagers who were willing to work for 1-10 days was 35.59 %, 30.16 % and 41.07 %, respectively in Kairu, Devrala and Nimriwali. It was also observed that significant number of landless people were also willing to volunteer themselves for the protection of plantations. Saxena *et al.* (2008) observed that out of total value of the habitat function, 77.88 % was contributed by the WTP in terms of their willingnessResearch Notes to work, while contribution in terms of direct money was only 22.18 % of the total value.

It has been estimated that even if the current efforts of plantations for mitigating wind erosion are continued @ ₹ 13,000/ha, at least ₹ 1,17,000 million would be required to replant the moderately and severely affected 8.74 million hectare in Western Rajasthan alone (Dhir and Venkateswarlu, 1996). Kulshreshtha and Korta (2009) estimated that the value of these external benefit amounted to over US$140 million. The majority of this value was derived from carbon sequestration (US$73 million) and reduced soil erosion (US$15 million) services with the remainder being contributed by biodiversity and water and air quality services. Other external benefits, such as health values, transportation safety, aesthetics and property values were identified but could not be estimated due to a lack of data. Since

these dunes are largely owned by the farmers as private property, participation of the regional farmers in sand dune stabilization and shelterbelt programmes will reduce the investment besides providing effective protection and overall management for productive biomass and environmental services for the livelihood security.

The study suggested that the locals in the arid region knew the importance of the plantation and were willing to participate in its conservation and development. The total value of regulation function was estimated at ₹ 1.20 million for the entire population of these villages. This value seems to be on the lower side, however, it is quite high when compared with the average annual income of the people, who are mainly agricultural workers having low average annual income. This value can go very high if the value of WTW (Average WTW x wage rate x Total number of HH) is added to WTP value. It can also become very high if the money spent by the government for clearing of the highways and railway tracks is added to this value. if the money spent by the government for clearing of the highways and railway tracks is added to this

Table 3

WTP if there is rise in agriculture income

WTP (% of ₹ 5000)	Villages		
	Kairu	Devrala	Nimriwali
Nil	18.64	15.87	17.24
<5%	33.90	61.90	62.07
5.1-10%	16.95	11.11	15.52
>10%	30.51	11.11	5.17

Table 4

Willingness to work in mandays

WTW (mendays)	Villages		
	Kairu	Devrala	Nimriwali
Nil	6.78%	9.52%	3.57%
≥1-10%	35.59%	30.16%	41.07%
11-25 %	27.12%	31.75%	42.86%
>25%	30.51%	28.57%	16.07%

Acknowledgements

The authors are thankful to the European Union Cross Cultural Programme for providing financial support for carrying out this study and to the Divisional Forest Officer, Bhiwani and all his field staff who provided wholehearted support during the field exercise.

SUMMARY

A study was conducted in Haryana, India to estimate the value of regulation function of planted forests related to the prevention of damage caused by wind erosion. The region is dry, sandy and barren with low rain fall. The crop production is adversely affected due to wind erosion. Contingent Valuation Method (CVM) was applied to assess local's willingness to pay (WTP) for raising plantations and its maintenance for mitigating the impact of wind erosion. The mean WTP was estimated @ ₹ 448.00 per house hold per annum, while the collective WTP of respondents for raising plantations was estimated @ ₹ 3049.00 per hectare per year.

Key words: Wind erosion, Ecosystem services, Willingness to pay (WTP), Plantation, Household.

रोपे गए वनों से परिस्थिति-संहति को मिलती सेवाओं का मूल्यांकन- वात अपक्षरण की रोकथाम-हरियाणा, भारत से किया एक विशेष अध्ययन

एन.एस. बिष्ट, एम.एस. गुसांई, सी.जे. सिंह व ए.के. हुड्डा

सारांश

हरियाणा, भारत में एक अध्ययन, रोपे गए वनों की वात अपक्षरण से होने वाली हानि की रोकथाम करने में उनके विनियामी कार्य के मूल्य का अनुमान लगाने के लिए संचालित किया गया। यह प्रदेश शुष्क, रेतीला और कम वर्षा होने वाला बंजर भूमि का है। वात अपक्षरण के कारण यहां का फसल उत्पादन कुप्रभावित होता रहता है। वात अपक्षरण से पड़ने वाले प्रभाव को कम करने के लिए रोपवन लगाने ओर उसके अनुरक्षण में स्थानीय लोगों की खर्चा उठाने की सहमति का आकलन करने को आवश्यक मूल्यांकन विधि को उपयोग में लाया गया। खर्चा उठाने की सहमति का माद्य ₹ 448.00 प्रति घर-परिवार वार्षिक रहता अनुमान किया गया जबकि प्रतिचारियों की सामूहिक खर्चा उठाने की सहमति, रोपवनों को लगाने के लिए ₹ 3049.00 प्रति हेक्टेयर प्रतिवर्ष अनुमानित की गई।

References

Chopra, K. and G. Kadekodi (1997). *Natural resource accounting in Yamuna basin: Accounting for forest resources, IEG monograph*. New Delhi.

Dhir, R.P. and J. Venkateswarlu (1996). Problem of wind erosion in relation to land use and management and control measures. In *: Soil management in relation to land degradation and environment*. (Eds. T.D. Biswas and G. Narayanasamy), Bulletin no.17, pp. 56-65. Indian Society of Soil Science, New Delhi.

Faroda, A. S. (1998). Desertification Control: Recent Technologies in the Indian Context. *Proceeding of the international symposium on new technology to combat desertification*. Tehran, 12-15 Oct.

FSI (2009). *State of Forest Report 2009*. Forest Survey of India, Ministry of Environment and Forests, Govt. of India, Dehradun, p. 199.

Gupta, J.P. (1983). *Soil and moisture conservation for increasing crop production in arid lands*. CAZRI Monograph No.20.

Gupta, J. P., A. Kar and A. S. Faroda (1997). Desertification in India: Problems and possible solutions. *Yojana* (Independence Day Special Issue on Development and Environment). August, 55-59.

Hadker, N., S. Sharma, A. David and T.R. Muraeedharan (1997). Willingness-to-Pay for Borivli National Park: Evidence from a Contingent Valuation. *Ecological Economics*, **21** (2):105-22.

Kulshreshtha, S. and J. Kort (2009). External economic benefits and social goods from prairie shelterbelts. *Agroforestry Systems*, **75** (1):39-47.

Kumar, S. (2001). Estimation and economic evaluation of soil erosion: A case study of Doon Valley in India. IEG Discussion Paper No. 23/2001.

Murty, M. N. and S. Menkhaus (1994). Economic Aspects of Wildlife Protection in the Developing Countries: A Case Study for Keolado National Park, Bharatpur, India. Institute of Economic Growth: Delhi.

Ramakrishna, Y.S., A.S. Rao, R. Singh, A. Kar, and S. Singh (1990). Moisture, thermal and wind measurements over two selected stable and unstable sand dunes in the Indian deserts. *Jour. Arid Environ*. **18**: 25-38.

Saxena, A.K., N.S. Bisht and C.J. Singh (2008). The value of Indian gazelle (*Gazella gazella*): a case study in Haryana, India. *Indian Forester*, **134** (10): 1289-1295.

Sheil, D., R.K. Puri, I. Basuki, M. van Heist, M. Wan, N. Liswanti, Rukmiyati, M. A. Sardjono, I. Samsoedin, K. D. Sidiyasa, Chrisandini, E. Permana, E. M. Angi, F. Gatzweiler, B. Johnson A. Wijaya (2004). Exploring biological diversity, environment and local people's perspectives in forest landscapes: methods for a multidisciplinary landscape assessment, Bogor, Indonesia, CIFOR, ISBN: 979-3361-29-8.

Venkateswarlu, J. and A. Kar (1996). Wind erosion and its control in arid north-west India. *Annals of Arid Zone*. **35**:85-99.