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Impact of participatory silvipastoral intervention and soil conservation measures for forage resource enhancement in western Himalaya

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ABSTRACT

Livestock rearing is an important component of rural economy in mid-hills of Himalaya. Inspite of abundant available feed resources, total available biomass is insufficient to sustain the livestock population. Fodder trees particularly in hill ecosystem play an important role in supplementing the fodder requirement especially during the lean period. Information gathered and analysis concludes that *Grewia optiva* is the most important fodder tree in terms of dominance, palatability and increase in milk yield followed by *Artocarpus chaplasha*, *Morus alba*, *Bauhinia variegata*, *Albizia lebbeck* and *Terminalia alata* in Kangra and Mandi districts of Himachal Pradesh. The crude protein content was found highest in *Grewia optiva* (19.38%) followed by *Albizia lebbeck* (18.85%), *Dendrocalamus hamiltonii* (18.01%) and minimum in case of *Quercus incana* (9.27%). During scarcity of fodder *Ficus religiosa* is the only fodder tree fed throughout the year. The established silvipasture produced leaf biomass of 2.77 to 6.77 DM kg/tree (Ghanetta), 2.12 to 5.96 DM kg/tree (Jogindernagar) and 2.25 to 6.93 DM kg/tree (Dagoh). Fodder trees planted under silvipastoral system produced average biomass of 1.83 DM tonnes/ha (Ghanetta), 1.49 DM tonnes/ha (Jogindernagar) and 1.66 DM tonnes/ha (Dagoh). Rainfall events of more than 50 mm, though quite less in number (25/165, 24/192 and 17/149), contributed 47.7, 82.3 and 81.7% to the total runoff at Ghanetta, Jogindernagar and Dagoh, respectively. Among the resource conservation measures trenching in combination with vegetative barrier allowed only 8.2% of rain as runoff compared to 41.5% under control (no measure). The silvipasture systems coupled with contour staggered trenches and / or vegetative barrier can effectively arrest the environmental degradation.

Key words: Fodder trees, Herbage, Himalaya, Livestock, PRA, Silvipasture, Soil conservation

Livestock rearing is an important pursuit in mid-hills of Himalaya. The climatic and land constraints have rendered crop production an uncertain and un-remunerative pursuit. In order to supplement cash income, farmers rear sheep, goats and cattle under sedentary, semi-migratory and migratory systems. Inspite of the abundance of the pastures, in mid-hills, sub-alpine and alpine areas, crop residues and grazing in the forests, common property resources (CPR) and wastelands, the total available biomass is insufficient to sustain the livestock population. The productivity of fodder in CPR lands is very low due to pine trees and infestation of *Lantana* and other obnoxious weeds (Pathania and Dev 2011). There is a gap of about 26 and 54% for green and dry fodder availability, respectively in western Himalayan state of Himachal Pradesh (Dev *et al*. 2006). Grazing, feeding of crop residues and use of fodder tree leaves are the major feed resources in descending order of extant use. All these sources are used individually without harmonizing their synergies. Consequently the process of degradation has rendered these resources too unproductive. The tree foliage is considered as potential protein and energy supplements to increase productivity of ruminants (Katoch 2009). The use of tree fodder is maximum during lean periods (winters), when trees provide almost 80% of the feed. The trees and shrubs also play a vital role in the control of soil erosion, nitrogen fixation, bringing economic benefits to the farmers and bridging the wide gap between supply and demand for

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animal feeds. The Himalaya supports 84 species of fodder trees and 40 shrubs, yet not more than 20 of these are used by the farmers. Fodder trees are also suitable for silvipastoral systems and are less affected by the climatic variations because of their extensive root systems. Silvipstoral systems have been found to be one of the most viable options for obtaining higher biomass per unit area. A large number of tree species are available for planting in the area, however, the choice of species from the farmer's perspective is always a better option. The study was carried out with the main objective of enumeration of fodder trees in a participatory mode for silvipastoral establishment and to study the impact of soil and water conservation measures.

MATERIALS AND METHODS

Ghanetta and Dagoh villages in Kangra district and Jogindernagar in Mandi district of Himachal Pradesh were selected through multistage stratified sampling methods for silvipastoral intervention on the community lands with active participation of native beneficiaries. A total of 15 farmers were selected randomly in each village and then classified into different farm sizes, i e marginal (0-1 ha), small (1-2 ha) and large (>2 ha). All the fodder trees growing in these areas were listed. Information on fodder trees were collected from selected farmers in each village through personnel interviews/key informant interviews/ participatory rural appraisal (PRA) methods/ focused group discussions (FGD) etc. The preference of fodder trees for silvipastroal establishment was done through FGD and matrix scoring. Information on role of farmers and farmwomen were also gathered through FGD. Fodder trees identified through PRA were analysed for proximate composition. The silvipasture and soil conservation measures were laid out during 2003 at Ghanetta (1100 m above msl with 124% slope), Dagoh (1020 m above msl with 106% slope) in Kangra district and Jogindernagar (1175 m above msl 81% slope) in Mandi district of Himachal Pradesh with active participation of native beneficiaries. At each sites, four paddocks measuring one ha each were planted with fodder trees (based on the matrix ranking) and introduced grasses/legumes. Two years old saplings of *Artocarpus chaplasha*, *Albizia lebbeck*, *Bauhinia variegata*, *Morus alba* and *Grewia optiva* were transplanted at 5m × 5m spacing with introduced grasses. The paddocks at each site were divided into four parts for imposing the treatments of soil & water conservation measures in three parts (trenching, vegetative barriers, a combination of trenching and vegetative barrier) and the fourth part kept as control (no soil conservation measure). Self recording rain gauge and multi-slot devisors with runoff collection tanks were installed at each of the three sites for recording event based rainfall and runoff data. The data on survival (%) and biomass potential of fodder trees is presented for the 6th year of silvipastoral establishment. The data were subjected to simple mathematical and statistical analysis.

RESULTS AND DISCUSSION

Bench mark survey

A comprehensive benchmark survey on socio-economic status (land holding, land details, head of family, family status, occupation and education), livestock, fodder consumption pattern, livestock rearing activities, fodder tree resource, feeding calendar, leaf biomass potential and preference of fodder trees done through various PRA exercises, FGD, key information interviews etc. at all the three locations is presented as under.

Socio-economic status of the farmers

Land holding

Socio-economic status analysis revealed that 82% (Ghanetta), 70% (Dagoh) and 78% (Jogindernagar) of the farmers were found in marginal category (Table 1). It was found that 13.39% (Ghanetta), 14.28% (Jogindernagar) and 18.57% (Dagoh) farmers had small landholdings. Only 4.47, 7.17 and 11.43% of the farmers were having large land holdings at Ghanetta, Jogindernagar and Dagoh, respectively. Data clearly signifies that most of the farmers were of marginal category.

Land details

Land put under fodder cultivation was only 0.05 ha

Table 1 Socio-economic status of the farmers

Attributes	Ghanetta	Dagoh	Jogindernagar
Land holdings (%)			
Marginal (<1.0 ha)	82.14	70.00	78.57
Small (1-2 ha)	13.39	18.57	14.28
Large (> 2 ha)	4.47	11.43	7.15
Land details (ha/family)			
Irrigated	0.51		
Rainfed	0.43	1.08	1.15
Land leased in	0.25	0.01	0.15
Land leased out	0.36	0.13	
Orchards	0.19		0.11
Fodder cultivation	0.05	0.04	0.04
Pasture land	0.27	0.64	0.20
Head of the family (%)			
Young (<25 yrs.)	3.57	5.71	2.85
Middle age (25-45 yrs.)	30.35	38.57	51.42
Old (> 45 yrs.)	66.07	55.71	45.71
Occupation (%)			
Labour	8.92	5.71	17.14
Agriculture	50.89	51.42	38.57
Agril. + Service	37.50	34.28	31.42
Agril. + Business	2.67	8.57	12.85
Education (%)			
Illiterate	19.64	15.71	18.57
Primary	30.35	44.28	31.42
High school	37.50	35.71	42.85
Graduate	12.50	4.28	7.14

(Ghanetta) and 0.04 ha (Dagoh & Jogindernagar) (Table 1). On an average each family had pastureland of 0.27 ha (Ghanetta), 0.64 ha (Dagoh) and 0.20 ha (Jogindernagar). Singh *et al*. (2009) in a study based on the IRSP6LISS3 imagery found that the area under grasslands was only 12.38%, 11.27%, respectively in Kangra and Mandi districts of the state.

Head of family (%)

Most of heads of the family at Ghanetta (66.07%), Dagoh (55.71%) were of >45 yrs age, while at Jogindernagar, 51.42% heads of family were of middle age group (Table 1). This is an important aspect as most of the decisions related to growing of crops/fodder/livestock and rearing activities are taken by head of the family.

Occupation

About 50% (Ghanetta), 38% (Jogindernagar) and 51% (Dagoh) farmers have adopted agriculture as main occupation followed by agriculture + service (Table 1), therefore indicating agriculture as the main occupation of these areas.

Education

Most of the farmers were educated up to high school followed by primary level education. A perusal of the data (Table 1) revealed that 37.50% (Ghanetta), 35.71% (Dagoh) and 42.85% (Jogindernagar) farmers were educated up to primary standard. Only 12.50% (Ghanetta), 4.28% (Dagoh) and 7.14% (Jogindernagar) farmers were educated up to graduation level.

Livestock inventory

Livestock inventory of the three villages is enlisted in Table 2. Cows, bullocks, buffaloes, sheep and goats were the animals reared by the farmers. It is evident from the data that average number of livestock increased with increase in farm size, showing thereby a direct relationship between land holding and animal population. Data indicated that cows/household were 1.42 (marginal), 1.68 (small), 1.93 (large) at Ghanetta, 1.34 (marginal), 1.51 (small), 1.68 (large) at Dagoh and 1.48 (marginal), 1.59 (small) and 1.87 (large) at Jogindernagar. On an average number of animals/ household reared by the farmers were 1.26 (marginal), 2.43 (small), 3.70 (large) at Ghanetta; 1.08 (marginal), 2.19 (small), 3.26 (large) at Dagoh and 1.06 (marginal), 2.32 (small) and 3.39 (large) at Jogindernagar. Under overall situation an average 1.13 (marginal), 2.31 (small), 3.45 (large) numbers of animals were reared by each household. Livestock kept by every household clearly signifies the importance of animals in hills. Singh *et al*. (2009) estimated the livestock population (number in ACU) of the state and reported 333734 (cattle), 162758 (buffaloes), 18091 (sheep), 33772 (goats) in Kangra district and 368821 (cattle), 84208 (buffaloes), 20547 (sheep) and 30947 (goats) in Mandi district, substantiating the importance of livestock in these areas. Dev *et al*. (2011) have observed that rural farmwomen have to spend far more time in livestock rearing activities.

Table 2 Livestock inventory (Number/household)

Category	Cows	Buffaloes	Bullocks	Goats	Sheep	Total	Average
			Ghanetta				
Marginal	1.42	0.67	0.82	1.41	1.98	6.3	1.26
Small	1.68	0.72	1.08	3.27	5.42	12.17	2.43
Large	1.93	0.81	1.12	5.84	8.78	18.48	3.70
Total	5.03	2.2	3.02	10.52	16.18	36.95	7.39
Average	1.68	0.73	1.01	3.51	5.39	12.32	2.46
			Dagoh				
Marginal	1.34	0	0.74	1.55	1.78	5.41	1.08
Small	1.51	0.41	0.98	3.57	4.47	10.94	2.19
Large	1.68	0.67	1.15	4.98	7.81	16.29	3.26
Total	4.53	1.08	2.87	10.1	14.06	32.64	6.53
Average	1.51	0.36	0.96	3.37	4.69	10.88	2.18
			Jogindernagar				
Marginal	1.48	0	0.68	1.1	2.02	5.28	1.06
Small	1.59	0	1.01	2.89	6.11	11.6	2.32
Large	1.87	0.57	1.28	4.52	8.69	16.93	3.39
Total	4.94	0.57	2.97	8.51	16.82	33.81	6.76
Average	1.65	0.19	0.99	2.84	5.61	11.27	2.25
			Overall				
Marginal	1.41	0.22	0.75	1.35	1.93	5.66	1.13
Small	1.59	0.38	1.02	3.24	5.33	11.57	2.31
Large	1.83	0.68	1.18	5.11	8.43	17.23	3.45

Fodder consumption pattern

Depending upon the availability of green and dry fodder, quantity of fodder fed to the animals varied significantly. During lean periods (January to March and October to December) more quantity of dry fodder was fed to the animals. During monsoon season, when availability of green fodder was substantial; animals were fed more green fodder. It was observed that animals were fed with meager quantity of concentrates. In order to supplement the feed requirement, by and large animals were grazed throughout the year. Average fodder consumption by cows (kg/day/animal) during different periods in a year is presented in Fig 1.

Fodder tree resource assessment and use

Farmers in these villages revealed that fodder trees supplement the fodder demand during the lean period. Important fodder trees found in these areas were *Grewia optiva*, *Bauhinia variegata*, *Dendrocalamus hamiltonii*, *Morus alba*, *Artocarpus chaplasha*, *Albizia lebbeck*, *Albizia stipulata*, *Terminalia alata*, *Ficus benghalensis*, *Quercus* sp, *Bombax ceiba*, *Acacia catechu*, *Cedrella toona*, *Robinia pseudoacacia*, *Celtis australis* and *Dalbergia sissoo*. *Grewia optiva* was most abundant fodder tree followed by *Bauhinia variegata*, *Albizia* spp and *Dendrocalamus hamiltonii*.

The use of tree leaf indicated that most of them are fed during October to March, when there is acute scarcity of fodder. Farmers revealed that during severe scarcity *Ficus*

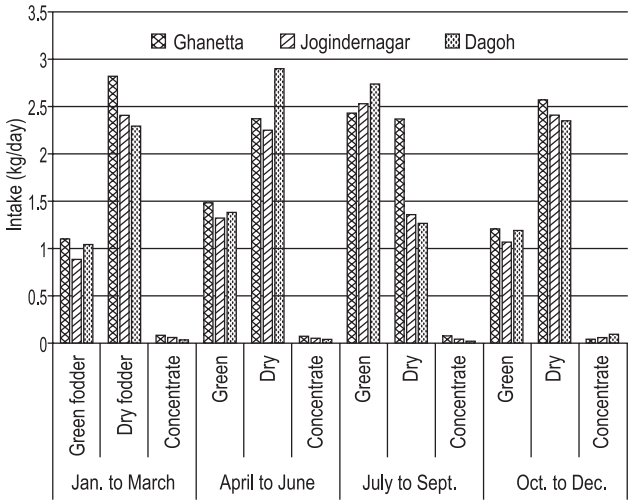

Fig 1 Fodder Consumption by cow (kg/day/animal) in selected villages

religiosa is the only fodder tree fed throughout the year. Use of leaf fodder devised by the farmers is a traditional management tool to avoid the feeding when anti quality factors are more prevalent in leaves. In alpine areas, the leaves of seabuckthorn were fed to animals from September to November. Twigs of *Salix* and *Betula* sp. were fed to the animals from March to April during alternate years (Dev *et al*. 2009).

Leaf biomass potential of dominant fodder trees

It was revealed by the farmers that leaf biomass production (FW/tree) of 12-15 kg (*Grewia optiva*), 15-20 kg (*Bauhinia variegata*), 25-30 kg (*Artocarpus chaplasha*), 22-25 kg (*Dendrocalamus hamiltonii*), 15-20 kg (*Morus alba*), 8-10 kg (*Quercus incana*), 10-15 kg (*Robinia psedoacacia*), 15-20 kg (*Terminalia arjuna*) could be obtained from a 6-8 years old fodder tree in a year. Age of lopping varied 6-8 years for most of the fodder trees. Subsequently the information provided by the farmers was substantiated under field and laboratory conditions.

Preference of fodder trees (matrix scoring)

Through various focused group discussions and PRA exercises it was found that at all the three sites *Grewia optiva*, *Dendrocalamus hamiltonii*, *Bauhinia variegata*, *Artocarpus chaplasha*, *Morus alba*, *Albizia lebbeck*, *Terminalia alata* were found to be the most preferred species. *Grewia optiva* was rated as the best fodder tree. *Dendraocalamus* was rated as the second most preferred species followed by *Bauhinia*, *Artocarpus* and *Morus*. *Dendrocalamus hamiltonii* as most profitable and fastest growing fodder plant (Table 3).

Proximate composition of selected tree forages (% DM)

Proximate composition of selected tree forages is presented in Table 4. Crude protein content in various fodder tree leaves ranged between 9.27 to 19.38%. The crude protein content was found to be highest in *Grewia optiva* (19.38%) followed by *Albizia lebbeck* (18.85%), *Dendrocalamus hamiltonii* (18.01%) and minimum in case of *Quercus incana* (9.27%). With regard to ether extract content, the higher value was found in *Morus alba* (5.75%), *Albizia lebbeck* (4.43%), *Ficus roxburghii* (4.33%) and minimum in case of *Bauhinia variegata* (2.69%). The crude fibre, which affects the digestibility varied in the range of 13.08 to 35.38% in different fodder tree leaves. Depending upon the crude fibre values, the fodder trees, viz. *Grewia optiva* (19.45%), *Morus alba* (14.38%), *Ficus roxburghii* (13.08%) and *Leucaena leucocephala* (14.02%) were considered to be the easily digestible fodder trees. Ash content was highest in *Morus alba* (14.59%), *Ficus roxburghii* (12.36%) and *Grewia optiva* (11.95%) and minimum in case of *Quercus incana* (6.57%). The nitrogen fibre extract (NFE) content was found minimum in *Dendrocalamus hamiltonii* (39.55%), and higher in *Grewia optiva* (45.18%) and *Bauhinia variegata* (45.38%). The chemical composition indicated that these species are good source of protein, mineral content and authenticates the farmer's perception. The high crude protein and a low content of crude fibre in the leaves were indicative of their higher nutritive values. Das (2009) has compiled importance of fodder trees in hilly areas and their nutritive values.

Table 3 Matrix scoring (10 high, 1=low) for fodder trees

Criteria	A	B	C	D	F	G	H	I	J	K	L
Better fodder	10	6	10	7	3		4	7	9	7	6
Better fuel	4	5	8	6	4	7	7	4	2	5	4
Better growth	3	4	9	6	4	3	5	4	3	3	2
Less after care	5	4	4	5	3	3	2	5	4	2	2
Economic returns	6		4	4			7		9		
Soil & water conservation	3	3	6	5	5	5	5	6	7	9	9
Total	35	25	47	37	23	21	34	32	38	34	32

A. *Artocarpus chapalasha*, B. *Terminalia alata*, C. *Grewia optiva*, D. *Bauhinia variegata*, E. *Toona ciliata*, F. *Dalbergia sisso*, G. *Acacia catechu*, H. *Albizia lebbeck*, I. *Dendrocalamus hamiltonii*, J. *Morus alba*, K. *Ficus religioasa*

Table 4 Proximate composition of selected tree forages (% DM)

Tree forage	CP	EE	CF	Ash	NFE
Acacia catechu	17.94	3.72	19.32	9.14	49.88
Albizia lebbeck	18.85	4.43	28.33	7.99	40.40
Artocarpus chaplasha	16.95	2.41	20.10	11.86	48.68
Bauhinia variegata	17.94	2.69	27.07	6.92	45.38
Dendrocalamus hamiltonii	18.01	2.34	28.27	11.83	39.55
Ficus roxburghii	13.81	4.33	13.08	12.36	56.42
Grewia optiva	19.38	4.04	19.45	11.95	45.18
Laucaena leucocephala	15.22	4.14	14.02	9.83	56.79
Morus alba	16.09	5.75	14.38	14.59	49.19
Quercus incana	9.27	4.20	35.38	6.57	44.58

CP – Crude protein, EE – ether extract, CF- crude fibre, NFE-nitrogen fibre extract

Table 5 Survival (%) of trees at three sites and biomass production

Site/Trees	Survival (%)	DM (kg/tree)	DM (tonnes/ha)
Ghanetta			
Albizia lebbeck	73.57	2.77	0.22
Artocarpus chaplasha	68.28	6.77	0.54
Bauhinia variegata	82.34	4.69	0.38
Grewia optiva	82.34	3.73	0.30
Morus alba	85.17	1.83	0.39
Jogindernagar			
Albzia lebbeck	75.67	2.12	0.17
Artocarpus chaplasha	68.73	5.96	0.48
Bauhinia variegata	92.37	3.80	0.30
Grewia optiva	92.17	3.00	0.24
Morus alba	90.21	3.78	0.30
Dagoh			
Albizia lebbeck	65.78	2.25	0.18
Artocarpus chaplasha	70.23	6.93	0.55
Bauhinia variegata	93.17	4.11	0.33
Grewia optiva	95.81	3.52	0.28
Morus alba	91.00	3.92	0.31

Silvipastoral intervention

Survival of fodder trees

Data on survival (%) of different tree species revealed that *Bauhinia variegata*, *Morus alba* and *Grewia optiva* had the highest (80- 90%) survival rate after six years of establishment at all the three sites, whereas *Artocarpus chaplasha* had the least survival (Table 5).

Leaf biomass production

Fodder trees in the silvipastoral system contributed substantially to the leaf fodder especially during the lean period through lopping. During 6th year of silvipastoral establishment fodder leaf biomass varied in the range of 2.77 to 6.77 DM kg/tree (Ghanetta), 2.12 to 5.96 DM kg/ tree (Jogindernagar) and 2.25 to 6.93 DM kg/tree (Dagoh). On an average all fodder trees planted under the silvipastoral system produced 1.83 DM tonnes/ha (Ghanetta), 1.49 DM tonnes/ha (Jogindernagar) and 1.66 DM tonnes/ha (Dagoh) (Table 5).

Soil and water conservation

The averaged data of 3 years (2003-2005) on soil and water conservation measures (Tables 6 and 7) indicated that runoff (% of rainfall) was highest at Jogindernagar (28.6%) followed by Dagoh (25.6%) and Ghanetta (16.3%) owing to their land slopes of 124%, 106% and 81%, respectively. Trenching in combination with vegetative barrier allowed only 8.2% of rain as runoff compared to 41.5% under control (no measure). Rainfall events of more than 50 mm, though quite less in number (25/165, 24/192 and 17/149), contributed 47.7%, 82.3% and 81.7% to runoff at Ghanetta, Jogindernagar and Dagoh, respectively to the total runoff.

Table 6 Runoff (% of rainfall) under different sites and conservation measures

Treatment	2003	2004	2005	Mean
Sites				
Ghanetta	13.9	18.7	16.3	16.3
Dagoh	26.4	27.4	22.9	25.6
Jogindernagar	26.6	31.6	27.5	28.6
Conservation measures				
Trenching	9.1	14.3	11.3	11.6
Vegetative Barrier	29.8	32.4	27.3	29.8
Trenching + Veg. Barrier	6.8	10.9	6.9	8.2
No Conservation measure - Control	38.9	44.3	41.3	4 1 . 5
Rainfall				
Ghanetta	1553	1622	1228	1468
Dagoh	846	1464	863	1058
Jogindernagar	1259	1566	1109	1311

Table 7 Runoff contribution under different rainfall classes

Daily rainfall (mm)	No. of events	Rainfall (mm)	Runoff (mm)	Runoff (% rainfall)
Ghanetta				
0-25	34.3	310.5	16.8	5.4
25-50	12.3	460.8	55.8	12.1
50-100	6.7	454.1	87.2	19.2
>100	1.7	242.3	69.1	28.5
Dagoh				
0-25	34.7	278.7	13.4	4.8
25-50	9.3	335.6	53.7	16.0
50-100	5.3	405.8	136.8	33.7
>100	0.3	37.8	18.1	48.0
Jogindernagar				
0-25	48.7	341.9	29.1	8.5
25-50	7.3	259.5	61.2	23.6
50-100	6.3	426.7	157.9	37.0
>100	1.7	283.4	128.4	45.3

Trenches formed in upper, middle and lower parts along the slope retained on an average 13.9, 16.6 and 19.1 cm sediments, respectively. Among sites, the sediment retention was highest at Dagoh (18.7 cm) followed by Jogindernagar (16.9 cm) and lowest at Ghanetta (14.0 cm). Dev *et al.* (2012) have observed that silvipasture is one of the most viable options for regenerating and improving the Himalayan grasslands. Therefore, silvipasture systems coupled with contour staggered trenches and/or vegetative barrier can effectively arrest the environmental degradation.

Therefore, introduction of locally acceptable fodder tree species in the silvipastoral system, higher CP content and their suitability for the livestock ensured the resource conservation substantially as well as the silvipasture systems coupled with contour staggered trenches and/or vegetative barrier can effectively arrest the environmental degradation.

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