Indian J. Soil Cons., 23 (2) : 119-128, 1995

AGROFORESTRY INTERVENTIONS IN DEGRADED MINED AREAS - A CASE STUDY

K. S. DADHWAL , P.L. SAROJ , N.K. SHARMA AND PRATAP NARAIN

Central Soil and Water Conservation Reasearch and Training Institute , Dehradun, 248195

ABSTRACT: Opencast mining, deforestation, uncontrolled grazing and unscientific landuse on steep hill slopes has resulted in unstable ecological equilibrium affecting the socio-economic condition of the local people. A detailed study on socio-economic profile, land holdings, inventory of farming assets, livestocks, source of onfarm and off farm income and employment, existing landuse systems and present situation of food, fodder, fuel and fibre as the basic needs was carried out during 1990-91 in the vicinity of degarded mined areas of Mussoorie hills in outer Himalyas of Uttar Pradesh. For better social acceptability, the farmers opinions were taken into diagnosis before designing some agroforestry models. Based on the diagnosed problems, comprehensive designs on various agroforestry aspects are suggested for uplifting the rural economy and rehabilitation of degarded mined areas. Alternative technologies have been put forward to enable farmers to opt for a befitting package. The suggested technologies are based on participatory rural approach as the farmers opinion is incorporated. The approaches are essentialy not top-down but bottom-up in nature calling for ready adoption. Under existing bio-physio-agro-ecological situations, ample strees has been given to integrate various agroforestry components and their scientific management for achieving desired targets.

Over exploitation of natural resources has resulted into serious land degradation problems throughout the globe. In India, various types of degradation problems including opencast mining have rendered about 175m ha of land either completely or partly unproductive (Bhumbla and Khare, 1985). Nearly 80,000 ha land of our country is presently under the stress of mining activity (Valdiya, 1988) out of which about 1400 ha is under Mussoorie hills causing serious environmental degardation (Juyal *et al.*, 1991). The unscientific mining, construction of hill roads, deforestation, overgrazing etc. have destroyed the perennial stream flows, deposited debris in the bottom valleys and converted productive lands into degraded lands. Considering these facts, the Supreme Court in its historic judgement in 1985 banned limestone quarrying in 55 mines of the area. Though, the unscientific mining is stopped but no specific emphasis was given for the upliftment of the victims residing in the adjoining areas. Therefore, this is the need of the hour to think for the rehabilitation of vast mined spoil areas by proper planning and scientific designing of agroforestry systems (AFS) so that the environmental stability can be restored for fulfilling the basic needs of the local community.

MATERIALS AND METHODS

With the broad objective including total stability of Mussooire hills, the Central Soil and Water Conservation Reasearch and Training Institute, Dehradun took up this challenge and started rehabilitation work on watershed basis at Sahastradhara during 1983. The watershed is confined to an area of 64 ha having two small tributaries joining the Baldi river. The work was intially started with the engineering measures and simultaneously followed by vegetative measures. The results obtained were quite promising and ultimately beneficial to the local people (Dadhwal

et al. 1994). It was Government funded programme with text book type top-down approach and no attention was given to the victims of the adjoining villages. Therefore, considering the needs and demands of the affected community, a survey based on diagnosis and design methodology was conducted by a mulidisciplinary team during 1990-91 to design the agroforestry models which are practically feasible and ecnomically viable under existing agroclimatic situations.

Study site

Sahastradhara is a picnic spot of tourist interest about 14 km away from Dehradun. The mine spoil area is in its vicinity where limestone quarrying has been done (Fig. 1). The adjoining villages were Dhandaula, Bogdadhuran and Nangalhatt. The geographic location of study site is 32° 23' N latitude 78° 8' E longitude. The elevation varies from 840 to 1350 m (msl) in the southeren aspect. The area belongs to subtropical climate with high rainfall during monsoon. About 80 per cent of the total annual rainfall is received from June to September. Winter rains are intermittent and mild. The average maximum temprature in May-June is 38° and lowest 1 to 3°C during December-January. Wind velocity is mild varying between 1 to 3.5 km hr^{-1}. No occurance of snowfall but occasional hailstorm do occur in Feburary-March. The geology of entire foothills is weak. The soil is gravelly silt loam to silty clay. The top soil consists of deposited debris and is completely disturbed having low moisture holding capacity and organic matter contents (Dadhwal *et al., 1992.).* The area falls under northern tropical deciduous

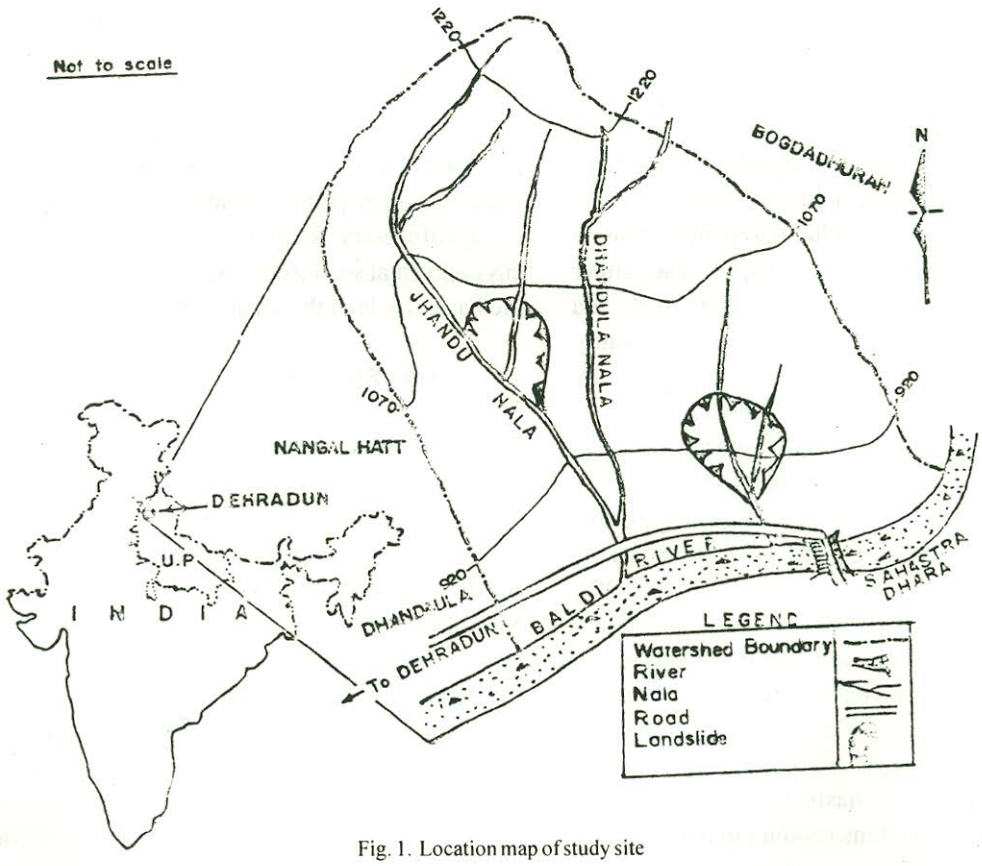

Fig. 1. Location map of study site

forest but due to high biotic interference the vegetation is very poor.

RESULTS AND DISCUSSION

Diagnostic phase

Socioeconomic profile : The socioeconomic survey was conducted in all the three villages and the relative information on population, literacy and size of land holding was recorded. The habitation was not so dense because of the poor infrastructural facilities. The average literacy percentage of Nangalhatt was more (66%) than Dhandaulla (40%) and Bogdadhuran (25%) (Tabel-1) Comparatively the literacy percentage of children was more than adults in all the villages, though the level of education was primary to junior high school showing the awareness of younger generations. Fifty farmers were contacted to know the average holding size of arable land. Although the population density of these villages was very low but the average holding size was only 0.67 ha due to the fact that a large area was highly degraded and presently not fit for arable farming. Majority of the farmers have holding size less than one ha.

Regular bus services are available upto Sahastradhara and from there these villages are connected by semi-pitch road. The telephone facility is also available in Nangalhatt village. The Dehradun city is the nearest market for all the villages. Rural water supply is also available in all the villages for drinking purpose. In village Dhandaula, there was only one family having a knitting machine being practiced as home industry.

Livestock details : Total livestock population in three villages was 171 (Table 2), averaging three cattle per family. The animal breeds were mostly local with exception in Bogdadhuran village having two improved buffalo breeds. The population of buffalloes was less as compared to cows due to fact that the movement of buffaloes on hills is difficult possibly due to heavy body weight. The milk produced by the milch animals is mostly used for the home consumption and is insufficient for the family requirements. In Bogdadhuran village few farmers were selling their milk to the local tea stalls at Shastradhara tourist resort to fetch additional income.

Table 2. *Village-wise livestock details*

Type of livestock	Village			Total
	Dhan-daula	Bogda-dhuran	Nang-alhatt	
Oxen	12	18	20	50
Cow	10	13	30	53
Buffalo	8	12	5	25
Calf	5	11	20	36
Horse	-	1	-	1
Poultry	6	-	-	6
Total	41	55	75	171

Table 1. *Population and literacy of the area*

Village	Population			Literacy percentage			Average
	Male	Female	Total	Male	Female	Childeren	
Dhandaula	75	75	150	30	10	80	40
Bogdadhuran	62	58	120	20	15	40	25
Nangalhatt	66	59	125	70	40	90	66

Source of income : Farming, although contributing 30-40 per cent of family income, is grossly insufficient to fulfil the basic requirements of families. Most of the villagers are, therfore, working as labourers in nearby town on daily wage basis (Table 3) which contribute 30-50 per cent of their income. The contribution of permanent services is more in Nangalhatt village as compared to Dhandaula and Bogdadhuran. This is probably due to high literacy. The contribution from home scale industries and dairying is negligible.

Table 3. *Source of income*

Source	Percentage contribution		
	Dhandaula	Bogdadhuran	Nangalhatt
Agriculture	41.5	40.5	30.5
Dairying	-	8.0	-
Home industry (knitting)	2.0	-	-
Temporary labourers	48.0	49.5	32.5
Permanent service	8.5	2.0	37.0

Basic requirements : Based on population of human and animals irrespective of villages the present availability and deficit for food and fodder was worked out. In all the cases there was shortage in food grain because of the traditional farming systems and rainfed conditions (Table 4). Cutting of shrubs and dry branches of the trees from the forest area are the main source of fuel. Few families are also using kerosine oil for cooking. There is no serious problem of fuel wood but definitely fodder availability was not sufficient, hence the cattle were underfed. Among top feed tree species, *Grewia optiva* is only planted unsystematically along the farm boundaries or on the bunds/risers.

Present landuse : The farmers are practicing traditional monoculturing without adopting suitable crop rotation. They are using locally available seeds and planting materials. The wheat *(Triticum aestivum)*, bengal gram *(Cicer arietinum)*, mustard *(Brassica compestris)*, masoor *(Lens esculenta)* and paddy *(Oryza sativa)*, maize *(Zea mays)*, mandua *(Eleusine corocana)*, red gram *(Ca janus cajan)* are the main *rabi* and *kharif* crops, respectively. No attention is given for growing of vegetables. There is no consideration towards green

Table 4. *Village-wise annual requirements, availability and deficit of food and fodder (tonnes)*

Particular	Village			Total
	Dhandaula	Bogdadhuran	Nangalhatt	
Food				
Human population (no.)	150	120	125	395
Food requirement	27	22	23	72
Food availability	4	6	7	21
Food deficit	23	16	12	51
Fodder				
Cattel population (no.)	35	54	75	164
Fodder requirement	250	385	535	1170
Fodder availability	125	195	295	615
Fodder deficit	125	190	240	555

manuring. They are also not using chemical fertilizers and plant protection measures. Farm Yard Manure (FYM) is used subject to availability in the farmstead. No attention is given to interculture operations. Due to lack of irrigation facilities the situation is further aggravated.

Agroforestry : The agroforestry is totally neglected under farmers conditions. *G. Optiva* is the only multipurpose tree (MPTs) retained either on farm boundaries or on the bunds/risers for fodder and fuel wood. Some naturally occuring sparse woody perennials were also noticed (Table 5). Among fruit trees, mango and guava are planted. The wild plants of peach , karonda and mulbery were also observed in the surveyed villages. There was no single orchard of mango except a declined guava orchard. However, in project area (64 ha watershed) a large number of natural occuring and introduced tree, shrub and grass species are growing based on the suitability of the site condition (Table 5).This was resultant to suitable planting techniques, care in initial establishment and fencing of the area. A major portion of the lower reach of the watershed

Table 5. *Existing and introduced vegetation*

Vegetation type	Natural	Introduced
On arable land		
Trees	*Grewia optiva*	*Eucalyptus* hybrid
	Mangifera indica	
	Ficus infectoria	
Shrubs and grasses	Not retained	
Non arable land		
Trees	*Toona ciliata*	*Eucalyptus* hybrid
	Bombax ceiba	*Leucaena leucocephala*
	Dalbergia sissoo	*Salix tetrasperma*
	Acacia catechu	*Psidium guajava*
	Grewia optiva	*Grevellia robusta*
	Sapium insignii	
	Mallotus phillipinensis	
	Casia fistula	
Shrubs and undergrowth	*Adhatoda vasica*	*Arundo donax*
	Lantana camara	*Ipomoea carnea*
	Vitex negundo	
	Ficus infectoria	
	Eupatorium glandulosum	
Grasses	*Cynodon dactylon*	*Eulaliopsis binata*
	Chrysopogon fulvus	*Pueraria hirsuta*
	Thysolaena maxima	*Sacharum spontaneum*
		Panicum maximum

was vegetated but still a large area is lying vacant on the steep slopes of upper reach. The major constraints identified in adopting agroforestry systems are lack of technical knowhow, small holding size, poor socioeconomic conditions and risk of yield decline of main crop due to competition for water, nutrients and light.

Major farming constraints identified :

- Traditional farming practices.
- Lack of irrigation facilities, hence moisture strees except in rainy season.
- Use of low yielding varieties.
- Insuficient use of manures and fertilizers.
- Poor knowledge about scientific crop management practices like crop rotation, cropping pattern, green manuring, mulching etc.
- Lack of plant protection measures.
- Improper weed management.
- Poor attention on cash and fruit crops.
- Rearing of local breed of milch animals.
- Unavailability of improved seeds/planting materials nearby the villages.
- Lack of communication, transport and marketing facilities.
- Least attention to home/cottage industries.

Farmers's likings :

- Farmers are interested to adopt high yielding varieties of crops to meet their food requirements.
- They are also interested to grow vegetables in rainy season as cash crops.
- They like to grow MPTs in homestead, farm boundaries and on the bunds.
- As the land holding size is small, farmers are reluctant to switchover to multistorey cropping systems especially by intergrating fruit plants as perennial component.
- Some farmers especially ladies are interested in small scale cottage industries.

Designing phase

The principle involved in designing agroforestry models is totally based on the basic needs of the people, economic viability of the system and its usefulness against degradation of natural resources (Lundgren and Nair,1983 and Nair,1984).

Major considerations :

- Diversification of agricultural crops (cereals, legumes, oilseeds, vegetables, fibre and green manuring crops) and adoption of appropriate crop rotation.
- Replacement of desi varieties (low yielding, long duration, poor quality) by improved ones.
- Integration of quick growing MPT species.
- Due consideration should be given to grow fruit crops.
- Appropriate soil working and timely sowing/ planting of seeds/planting materials.
- Proper care of soil moisture, plant canopy, weed, pest and disease management.
- Besides FYM and compost ; recommended dose of chemical fertilizers should be applied.

Agroforestry and basic needs

Based on the diagnostic survey of the socioecnomic profile, livestock details, existing landuse systems, prevailing management practices and various biophysical farming constraints in the adjoining villages; some AFS have been designed for fulfilling the basic needs as well as rehabilitation of degarded mined areas.

Food requirement : One of the main reasons of poor yield and income is traditional farming local crop varieties must be replaced by high yielding, short duration, early maturing and hardy ones . Some of the important varieties suitable are given in table 6. Integration of various crops in a definite

Table 6. *Improved varieties of fruits, vegetables and agronomical crops*

Fruit	Vegetable	Crops
Mango	**Tomato**	**Paddy**
Dashcheri	HS-101	VL-206,Mazhera 3
Amrapali	Pusa Ruby	
	Angurlata	
Guava	**Brinjal**	**Maize**
Allahabad Safeda	Azad,Kranti	Naveen,Sweta,
Chittidar	Pusa Purple Long	Ageti-76,VL-42,15
Peach	**Radish**	**Cowpea**
Flordasum	Japanese-white	Pusa Falguni,
Prabhat		C-152
Shan-e-Punjab		
Pear	**Okra**	**Pigeonpea**
Patharnakh	Pusa Sawni	T-21, UPAS 120
Thum Pear		
Plum	**Bitter gourd**	**Ragi**
Santarosa,	CO-1	PES 176, 101,
Jamuni		VL-2042,HR-374
Mandarin	**Bean**	**Kodo**
Kinnow	Kentuky-	VL-8, Nivas-1
Nagpur Santra	Wonder,Premier	
Lemon	**Pea**	**Wheat**
Eureka Round	Arkel	Sonalika,
Pant-1	Boneville	HD-2021,1981
		HB-208
Litchi		**Barley**
Culcuttia		Kailash,Himani,
Seedless		Dolma
		Lentil
		T-36, Pant L 406
		631, VL Masoor-I-1
Saroj *et al.* (1994)	Anonymous (1984)	Singh *et al.* (1990)

pattern of crop rotation based on suitability of growing conditions not only diversifies the various farm products but also increase the overall productivity and restore the site conditions. The suggested rotations are : paddy-wheat, paddy-toria/mustard, maize-wheat, mandua/ragi-bengal gram, red gram/black gram-wheat, green manure-paddy-wheat, fallow-wheat etc. In most of the cases intercropping has additional advantage over monocropping. There are some tested intercropping systems suitable for these conditions eg. maize+cowpea (1 row of maize + 2 rows of cowpea)

and wheat+mustard (9 rows of wheat + 1 row of mustard).

Fuel, fodder and fibre : There is no serious problem of fuel due to access of people for head load cutting of fuel wood from forest. In addition, they also use dung cakes. Very few families are using kerosine oil for cooking purpose. To meet out the fodder requirement, adoption of silvipastoral system is very essential. The suggested top feed tree species are : *G. optiva*, *Bauhinia purpurea*, *Leucaena leucocephala*, *Morus alba* with *Chrysopogon fulvus*, *Panicum maximum*, *Eulaliopsis binata* grasses. Besides, other crop residues and harvested grasses the green fodder obtained from maize-cowpea intercropping system can be utilised well for feeding cattle. For the fibre sun hemp (*Crotolaria juncea*) can be grown. The thinner twigs of *G. optiva* can be used for extraction of fibre.

Animal products : Only 50 per cent farmers are having livestock. Hence, rearing of one or two livestock seems to be essential. Since the per family land holding is small, fragmented and undulated, therfore, rearing of draft animal is also essential. Opening of dairy industry by improved milch breeds is only possible by ensuring supply of sufficient green fodder and dry concentrate. Based on the social acceptability rearing of pigs (for meat), goat (for meat and milk), sheep (for milk, meat and wool) and poultry (for meat and eggs) are very profitable propositions. They also provide organic manure for fields.

Other needs : For engaging family members and to generate income and employment sericulture, bee keeping, cutflower, rope making industry, fruit processing and knitting units as homescale/cottage industries may be very useful.

Agroforestry systems : Integration of components on the same piece of land is more useful for production and ecorestoration. Therfore, crops can be integrated with various MPTs. The important MPTs which can be integrated in a silviagriculture system are ; *M. alba, L. leucocephala, Albezia lebbek, Dalbergia sissoo, G. optiva, B. purpurea, Toona ciliata* etc. The important fruit trees which can be integrated in agrihorti system are: *Citrus lemon, Psidium guajava, Prunus persica, Prunus domestica, Syzygium cumini* etc. The perennial top feed tree species have already been suggested for the integration in silvipastoral system. It is also suggested that at later phase of plant life when plant canopies are fused together growing of rhizomatous crops like ginger, turmeric, colocasia is more profitable when it is difficult to grow most of the agronomical and vegetable crops because of the shade effect. The system of plantation may depend upon the need and site specification like inter, boundray, hedge, single or double row, close or wide planting etc.

Agroforestry and non-agroforestry interventions

Possible agroforestry and non agroforestry interventions in relation to diagnosed problems are given in Fig. 2

Resource management

Adoption of AFS itself is sufficient to prevent further degardation of natural resources. Even then, some of the basic considerations are suggested to give the sound footing for the adoption of agroforestry and rehabilitation of degarded ecosystem as follow :

- Clear felling should not be allowed in erosion prone areas.
- High yielding and palatable grasses should be planted on the bunds, risers and waterways.
- On hilly terrain; provision of staggered trenching, contour trenching, halfmoon

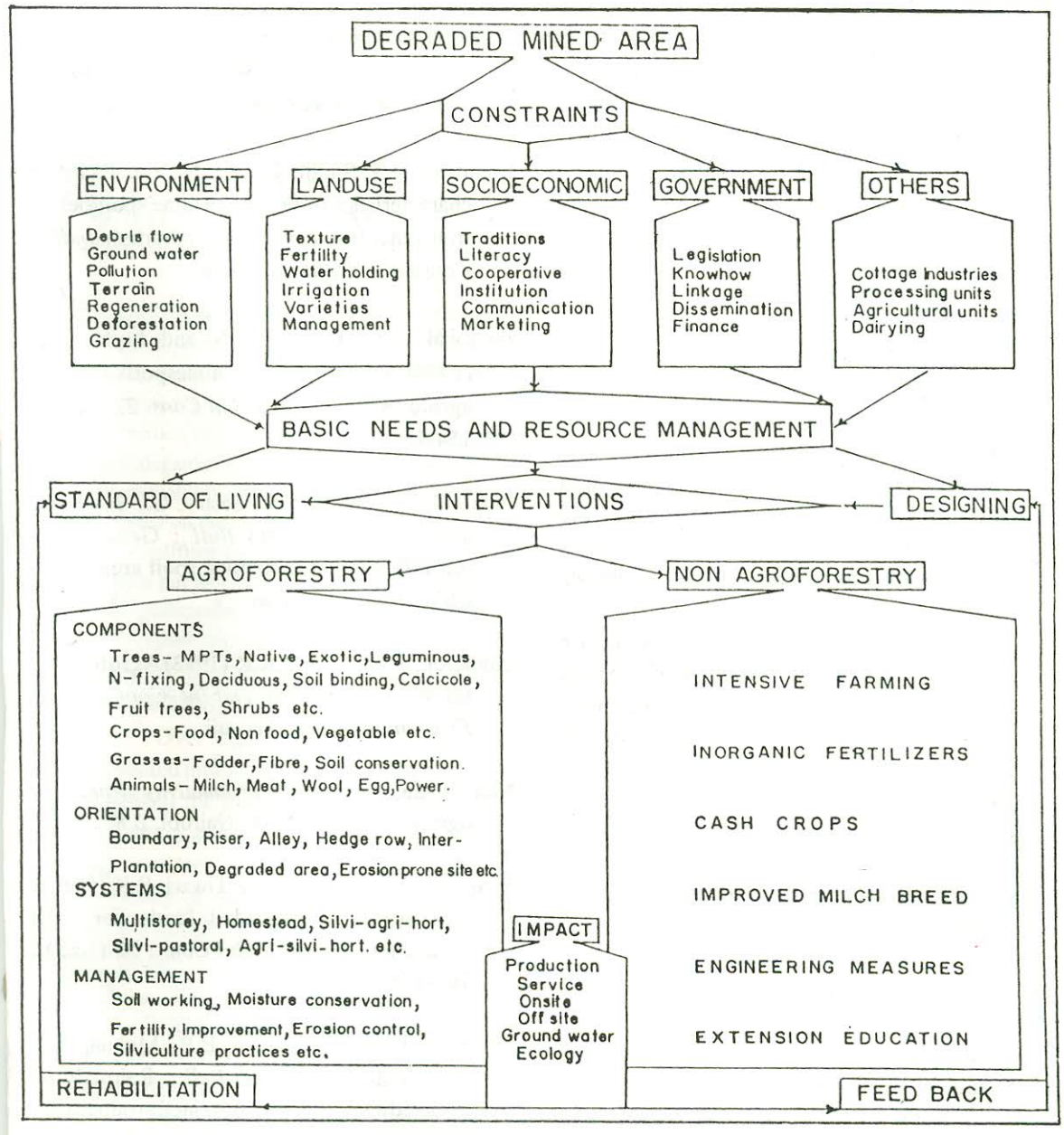

Fig. 2. Diagnosis and designing of agroforestry and non-agroforestry interventions for degraded mined area

basin, ring basin with 5 per cent inward slope etc. give better plant establishment.

- On slopy lands hedge row cropping is very useful in reducing runoff and soil loss.
- On the contours, planting of *Agave* species and/or pineapple acts as vegetative barrier.
- On very steep slopes (30-70%) mulching, use of geotextiles and planting of grasses is suggested.
- Planting of multipurpose trees by adopting suitable soil working techniques eg. pits, holes, placing and mixing of normal soil,

manuring, fertilization, watering etc is recommended.

- Channelization of rainwater and provision of drains, gully plugging and brush wood check dams should be made as per need.

Further suggestions

- Farmer should approach the government officials and local political leaders to establish better communication and transportation facilities, educational institutes, water supply and electrification.
- Contact with block officers be made to open a small agricultural unit nearby the villages so that they can get seeds of improved varieties, fertilizers, plant protection chemicals, low cost agricultural equipments etc.
- Educated and unemployed youths are suggested to take help from the government agencies and banking sectors for opening of dairy, small shop and/or establishment of homescale industries.
- Villagers are also advised to facilitate the voluntary organizations, working for the welfare of the rural mass as well as ecorestoration and subsequently they can derive benifites from them.

ACKNOWLEDGEMENT

Authors are highly grateful to Director, Centra Soil and Water Conservation, Research and Training Institute, Dehradun for inspiration and providing necessary facilities during the course of this investigation.

REFERENCES

Anonymous (1984) *Tech. Bull.* NEH Region, ICAR (1975-1984)

Bhumbla, D.R. and Khare, A. (1985) *Estimates of Wastelands in India.* Soc. for promotion of Wastelands Development, New Delhi.

Dadhwal, K.S. Singh, B. and Narain, P.(1992) characteristics of limestone mine spoil/debris from outer Himalayas of Uttar Pradesh. *Indian Forester, 118* (9) : 650-658.

Dadhwal, K.S., Katiyar, V.S. and Juyal, G.P. (1994) Rehabilitation of minespoils through agroforestry. *Indian J. Soil Cons.* 22 (1&2) : 154-161.

Juyal, G.P., Katiyar, V.S., Sastry, G., Singh, G. and Joshie, P.(1991) *Bull* : Geojute for rehabilitation of steep mine spoil areas. p-2., CSWCRTI, Dehradun.

Lundgren, B. and Nair, P.K.R. (1983) Agroforestry for soil conservation. *2nd Int. Conf. on Soil Erosion and Cons.,* Hawaii.

Nair, P.K.R. (1984) *Soil productivity aspects of agroforestry.* INCRAF, Nairobi, p.85.

Saroj, P.L., Dubey,K.C. and Tiwari, R.K. (1994) Utilization of degarded lands for fruit production. *Indian J. Soil Cons.*, **22** (1&2) : 162-176.

Singh,G., Tyagi, P.C., Joshi, B.P., Mohan, S.C. and Singh, P.N. (1990) *Bull.* : Rainfed and irrigated agriculture for sustained productivity. 55-66.

Valdiya, K.S. (1988). *Enviromental impact of mining activities.* Mining and Environment in India. H.R. Publisher, Tallital, Nainital (U.P.) p. 29-42.

Received May 1994