Strategies for Soil Conservation and Watershed Management in Siwaliks, India

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Abstract: Siwaliks boardering the southern part of Himalayan mountain have been completely denuded during the last century. This denudation could of course attributed to loose fragile mass, scanty vegetation and erratic rainfall, but mainly on account of poor land management and over exploitation of land resources. Conservation and management of natural resources employing the modern concept of watershed management holds the key for holistic approach for sustainable restoration of ecosystem of an area. The holistic approach of Integrated Watershed Management in Siwaliks is a recent effort and was first applied at Sukhomajri in 1975 and successfully achieved the goal of soil conservation linked with farm and forest land production with people's participation. Under the project 10 earthen dams were constructed in the hill to provide supplemental irrigation to farm lands. In a period of 10 years (1976—1985) about 96 ha forest catchment was treated with soil and water conservation measures and about 452,400 $m^3$of water storage capacity was created to provide life saving irrigation to 182 ha of farm lands in the valley area.

The success sotry of Sukhomajri watershed management was replicated in the entire region of Siwaliks of North India. More than 109 Sukhomajri type projects were completed in Siwalik Foothill region of Haryana and Punjab alone by the end of 1990—1991 at a cost of 55.16 million rupees. The overwhelming success of these watershed management projects easily convinced the Government of India to take up this program in a much bigger way in Hilly and undulating rainfed areas of other States. Forty seven National Watersheds were identified and managed by ICAR and SAU's under the umbrela of National Watershed Development Project for Rainfed Agriculture. This paper discusses the various strategies of soil conservation in important watershed development programs like Bhaintau Watershed at Fakal, Bunga and Nada Projects near Chandigarh, Relmajra Watershed near Ropar, Intergrated Watershed Development for Hills in parts of Haryana, Punjab, Himachal Pradesh and Jammu & Kashmir and including the pioneer watershed development project Sukhomajri in Siwaliks of India.

Keywords: siwaliks, watershed development, soil conservation, soil erosion, rainfed

1 Introduction

Siwaliks sandwitched between the Himalayan mountain in the north and Indo-Gangetic plain in south were once known for their lush green vegetation, now give a conspicuous example of man made ecological degradation. In this process he burnt and cut vegetation, fell trees, overgrazed and browsed the land surface, fell trees, overgrazed and browsed the land surface indiscriminately to satisfy his greed which resulted in soil erosion and land degradation (Gorrie, 1944). This process started about 150 years ago continued defying sketchy solutions (Mishra and Sarin 1987).

The Siwaliks deposited during 2.5 to 20 million year ago consisting of loose fragile mass of sand, silt, clay and anglomerates, and boulders of sandstone, schist and quartzites from Jammu & Kashmir to Assam require almost similar type of strategy and technology for their amelioration.Here in this paper efforts have been made to discuss the various technologies and strategies used for watershed development in Siwaliks right from the Sukhomajri-a pioneer watershed development concept of seventies to Integrated Watershed Development Project (Hills-II) phase II launched in new millennium (1999—2000) in the States of Uttar Pradesh, Haryana, Punjab, Himachal Pradesh and Jammu & Kashmir.

2 Sukhomajri - a pioneer concept of watershed development

(1) Sukhna to Sukhomajri: Sukhna lake was planned as an integral part of the master plan of Chandigarh city as a place of relaxation, seculation and sports. It was constructed in 1958 across Sukhna *choe* with a capacity of 10.74 million cubic metar (mcm) of water in a area of 2.28 km^2. The lake has catchment area of 42.07 km^2. in Chandigarh, Haryana and Punjab which is drained by two seasonal riverlets Kansal and Nepli the seasonal rivulets originate in Haryana.

Right from its construction heavy sedimentation with a rate of about 141 t/(ha • yr) has been a major cause of concern. This was mainly due to steep clopes of fragile and unstable Siwaliks. The reconnaissance survey conducted by scientists revealed that the major source of sediment was in the catchment area situated in close proximity of Sukhomajri and nearby villages in Haryana (Grewal *et al.*, 1997). This is how the concept of Sukhomajri watershed development evolved.

(2) Operational Research Project: Sukhomajri watershed development was started in Haryana in May 1975 by the Chandigarh Centre of CSWCRTI Dehradun. The problem in this area was so acute that by the year 1968, several agricultural fields were converted into 20 m deep and wide gorge from uncontrolled water coming from 4.2 hectare hilly catchment.

Under the project 10 earthen dams were constructed in the hills around Sukhomajri providing the facility of supplemental irrigation to farm lands of adjoining villages. In a period of 10 years (1976—1985), 95.6 ha forest catchment was treated with soil and water conservation measures in and around Sukhomajri and 452,400 m^3 of water storage capacity was created at a cost of Rs.16.12 lakh, to provide life saving irrigation to 182 ha of farm lands located in the village area.

(3) Vegetative Measures: The mechanical measures were supported by vegetative measures including planting of tree species like *Accacia catechu, Dilbergia sissoo* in the pits and slips of *Eulaliopsis bianata* on the mounds of trenches and hill slopes. *Agave americana* was planted in the critical areas to protect the soil against erosion. *Ipomea cornea* was planted in the channels. All these measures were aimed at containing surplus rain water and sediment *in-situ.*

(4) Peoples Participation: The new concept of demonstrative fields of major crops by irrigating agricultural fields from harvested rainwater brought tremendous motivation among the villagers. Seeing the response of the people's involvement and participation it was decided that the management of the project should be handed over to a village based society. Ultimately on September 12, 1981 a village society was constituted called 'Water Users Association' (WUA). This was duly registered under Society Registration Act, 1860. After twenty year the benefit cost ratio of the project worked out was 1.8 (Arya & Samra, 1995).

3 Operational research project fakot

Based on the experience of Sukhomajri Watershed here emphasis was given on 'demonstration approach' and subsidies. The 'Saturation approach' adopted at Sukhomajri required huge expenditure for construction of dams. The project was aimed to get more benefits with less expenditure incurred by the Institution & Food Foundation by demonstrations at selected areas in different toposequences. The main objective of ORP was to improve the productivity of the area while reducing the erosion hazards and to identify the various technologies and constraints of the areas.

(1) Project Area: The project area is located in the lower Himalayas 37km. from Rishikesh. About 370 ha area of the project forms a part of the Hiul river catchment, a tributary of the Gauges. About 22 % of the area is under reserve forest and 56% under Civil & Soyam lands. So, only 22% is left for agriculture. The average annual rainfall is 1,900 mm out of which 48% goes as runoff.

(2) Technology Adopted: The important technologies adopted are, bench terracing, gules and water storage tanks apart from the crop demonstration for improved rainfed agriculture- the main thrust of the project was carried in an area of 1.5 ha. This include irrigated as well as unirrigated terraces. About 2,110 m long gules were constructed out of which 1,500 m existing gules were repaired and reconstructed. As a result 10.5 ha additional land was irrigated. Five small tanks of 11.6 m^3 capacity of water were also constructed along with two existing tanks were repaired. Demonstration fields of cereals, fodders and orchards were laid out in 77.7 ha, 11.89 ha and 9.5 ha respectively. The project was evaluated for the

period of 1975—1982 and was found that with a small expenditure of *R*s.242,110/ about *R*s.21,000/ additional income was generated besides 2,600 and 2,200 profitable fuel wood and fruit trees in the ORP area. Apart from this nearly 18,000 mandays of direct employment were generated and soil erosion problems were also controlled to great extent.

4 Bunga watershed management

Bunga watershed is a typical of the Siwaliks foothills. The problems faced during Sukhomajri concept were tried to solve right from the beginning of the project. Over-grazing and large scale denudation were the main problems of the watershed. The project plan was prepared by the regional research station of CSWRTI Chandigarh and implemented by the soil conservation section of Agriculture Department of Haryana financed by Government of India.

(1) Project Area: Bunga watershed covering an area of 463 ha is located at village Bunga in earst while district of Ambala on Panchkula-Ambala road about 35 km from Chandigarh. The area falls in dry, sub-tropical & sub-humid agro-ecological zone of India with a annual average rainfall of 1,115 mm and temperature range of 0.25℃ in winter to 30℃—45℃ in summer. The hill rocks are quite young, soft and loose highly susceptible to erosion. The soils are mostly either Ustorthents or Ustorchrepts (Shanwal *et al.*, 1988; Kumar *et al.*, 1989). More than 60% soils fall under Class Ⅳ according to land capability classification.

(2) Mechanical measures: The measures include earthen dam, staggered contour trenches and stone checkdams. A earthen dam of 16 m height was constructed to harvest rain water from 154 ha forest catchment. The reservoir, thus, created had a water storage capacity of 59.6 ha m and spread area of 11.7 ha. The stored rainwater was taken to 243 ha of agricultural land in command through four underground steel pipe lines varying in diameter from 80 mm to 133 mm with a total length of 7,739 m. The estimated cost of the dam was Rs.9,30,000/. The dam with above specification has been checked for its stability (Dhruva Narayana and Sastry, 1986) and found the dam safe against all forces.

(3) Bioremedial Measures: On the berms of the contour trenches *Acacia catechu* was planted for their stablization and to provide fodder. *Eulatiopsis bianata* was planted on *berms* of the trenches and hill slopes. In the gully bottoms and areas with better moisture regime condition, *Delbergia sissoo* was planted. Fifty spurs were planted in order to train the *choe* and thereafter *eucalyptus hybrid* and *Dalbirgia sissoo* were planted on both sides of the *choes* for the further strengthening the mechanical measures supported by vegetative spars there was sharp decline in the sedimentation rate from 768 t/(ha • yr) to 240 t/(ha • yr).

(4) People's participation and benefits: The Hell Resource Management Society was constituted in 1985 on the lines of sukhomajri concept. The mean annual income of the society was Rs. 3,000 form the lease of grasses, Rs. 3,500 from fish and Rs. 12,500 from the sale of irrigation water from these sources, a social fund of about Rs. 19,000 is generated every year. Apart from this there was an increase in gross income among villages by 86 per cent after the project. The per annum milk production increased from 231,000 liters (1983—1984) to 723,000 liters (1991—1992). Fodder production also increased by 144 per cent. In terms of ecological restoration major achievement was decline in rate of sedimentation from 770 t/(ha • yr) to 240 t/(ha • yr) within a span of 10 years.

5 Nada project

The project was undertaken in Nada village, located at a distance of 15 kms from Chandigarh. It has four small hamlets. Three hamlets inhabited by a caste of *Lavana* just like *Gujjars*, and the fourth hamlet is inhabited by *Dalits* (*Chamar*). Most of the *lavanas* own lands supported by Livestock farming. On the other hand 33 per cent families of Delits were completely landless while others have less than 2 ha.

(1) Conservation technology and social fencing: Based on the earlier experience of other watershed the project authorities constructed 3 dams, 2 to irrigate Lavana's agriculture land and 1 for *dalits*. Similarly two separate village societies were formed. However, *Lavanas* resisted these concept on the plea that each family being entitled to an equal share of water. This was done with the concept of social

fencing could be put to a critical test. The major root course of conflict in all cases was the insensitively of the interventions in terms of equality.

(2) Lessons of the project: The case of Nada project amply demonstrate that the replication of Sukhomajri model a homogenous society in a heterogeneous social situation is fraught with intricate issues of social sustainability.

6 Relmajra watershed

The watershed is somewhat different from the other watersheds in Siwaliks in a sense that it is mainly infested with *choes* where the soils are sandy and starts flowing with water during high intensity rainfall.

(1) Project area: The project area is located in village Relmajra in district Ropar (Punjab). It is about 9 km in the north from Ropar and constitutes the catchment area of Satluj river. There are as many as six *choes* which drain the water from six independent sub-catchments. In this area lower Siwaliks composed of sand and clay are exposed which are very susceptible to erosion. Land slides and mass movement of sand as *choe* are the common features of the area.

(2) Bioremedial measures: To check the mass movement of soil bioremedial measures were first line of defence contrary to the other watershed whereas it supported the mechanical measures as second line of defence. The important grasses and herbs which acted as a barriers against soil erosion. The important tree species which successfully reduced the impact of high intensity rain drops causing splash erosion were established.

(3) Mechanical measures: Water harvesting dam was the sole component of the mechanical measures which was used for water harvesting, storage and recycling for watershed protection and improving biological productivity was the secondary measure. This endeavor also expected to promote social fencing by regulating biotic pressure.

An earthen dam was constructed across *Badholi choe* in the hilly area of the Relmajra watershed during 1992. The dam is 13.5 m high with a storage capacity of 13.7 ha. M having 59 ha catchement area of mixed forest and steep slopes.

(4) Alternative land use: In the common land, below the dam and upto the beginning of cultivated fields, different alternative land use system of largely hortipastoral, silripostoral, horticultural and agroforestry were adopted. Kinnow and Bhabbar was the most successful hortipastoral alternative land use on relatively flat areas made available due to the stream channelization.

(5) Community participation: The peoples involvement infact started right from the day one when some of them were employed on daily wages for various works carried out during the implementation of the project. This not only provided them employment for money sake but also evolved a feeling of ownness because it was imperative that the benefits of the project would go to them. To male the involvement of people a successful a water Users Society (WUS) was formed and registered under the Societies Registration act XXI of 1860. The society has 19 members on its sole. Taking into account of all the benefits and costs of the project with 20 years life and 12 per cent discount rate, the benefit, cost ratio was arrived at 1.20.

7 Integrated watershed development project for hills

When isolated, inadequately funded state efforts did not yield much, a nine years multi-sectoral World Bank aided Integrated Watershed Development (Hills-1) Project (IW DP, Hills^{-1}) also known as '*Kandi* Project' was launched in May 1990 with a total some of Rs. 2,519.5 million in Punjab Himachal Pradesh and Jammu and Kashmir. This was a multi pronged project involving state departments of forest, horticulture, animal husbandry and Agriculture. State Agricultural Universities were entrusted to evolve site specific technology and monitoring evaluation of the project work.

(1) Soil and water conservation technology: Although the Siwaliks extend from Jammu and Kashmir to Assam yet their geoenvironmental and socioeconomic conditions of the peoples are similar. Therefore, the technology adopted in the project area of all the four states are on similar guidelines given by World Banks with minor modifications based on the geological material of Siwaliks exposed (Lower, middle

and upper Siwaliks).

(2) Drainage line treatment: The soil erosion problems which emanated from the degradation and denudation of Siwaliks was mainly responsible for their further extension. Various drainage line treatments activity were under taken to check serious gully erosion problems. The treatments included crate wire structures, earthen gully plugs, masonary cement structures, dry stone meson any structures, small stone check dams, vegetative check dams, runoff management structures, vegetative spurs, sub-surface dams (SSD) village ponds (VP) and small water harvesting structures (WHS). Unlike to earlier watershed projects the approach was different and major funds were diverted towards WHS, SSD, VP for providing irrigation and drinking water for villagers.

(3) Bioremedial measures: A major portion of total project investment (60%—70%) was utilized for afforestation (A. *catechu, D. sissoo, M. agadirach, T. arjana, A. nitotica, H. integifolea, A. lebak* and *E. camaldulensis*), silvipasture (A. *catechu* with *stylo* and *E. blaneta*), Agaihorticulture (*Pomegranat Amla* with *Lentil*/*urad-wheat* or *maize*/*millet-wheat* cropping sequence) and vegetative shrub barriers (*Vetiveria zizaniodes*, *Eulaliopsis bianata*) on field boundaries and denuded and degraded lands with steep slopes. As a result the soil loss was brought down from 419 t/(ha • yr) to 5.0 t/(ha • yr) in span of 9 years.

(4) Animal husbandry: The local breads of low yielder animals were improved through artificial insemination (A.I.). Assistance was given to owners of milch animals in the form of supplementary ration for pregnant animals. To make the people of the area more animal health conscious, new Veterinary Hospitals and Dispensaries were constructed.

(5) Site specific technology development: As stated above all the SAU's were entrusted to develop site specific technology for soil and water conservation.

From the results of all the SAU's it was observed that *vetiver* and *bhabber* (2. rows each) combination was found most effective in arresting the soil erosion. V-ditch system of tree plantation was most effective in combating the soil erosion as well as conserving the moisture for plant growth (Shanwal *et al.*, 2001 and Panwar *et al.*, 2001). Various Agriforestry models (Agrihorticulture, Agrisilviculture and Silvipastoral) were developed for different areas depending upon soil type, slope and climate.

(6) People's participation and benefits: From the experience of earlier watershed projects the local peoples were involved right from the micro level planning to egalitarian distribution of cost and benefits. To achieve this 50 village development committees (VDC) were constituted and got registered under the firm and Society act, 1860.

People of the project area derived multiple benefits from the activity under taken by the project in their villages. This was clearly indicated by the monitoring and evaluation team of SAU's scientists. The report revealed that impact on employment generation was higher followed by availability of grasses from forests and increase in milk yield, reduction in soil erosion, increase in fruit trees and yield of crops, appreciation of land value and improvement of socio-economic status of people.

8 Integrated water shed development project (hills-II)

The success story of Integrated Watershed Development Project (Hills-I) could easily convince the World Bank (WB) for its continuation and WB extended the project for another five years in September 1999 with much bigger physical and financial allocations in the states of Haryana, Himachal Pradesh, Jammu and Kashmir, Punjab and Uttar Pradesh.

The project Would be focused on sustainability and replicability of the project activities through people's participation in general and women's involvement in particular. It is hoped that phase-II of IWDP (Hills-II) would be more be more remunerative, reduce the gap between rich and poor, improve the overall living standard of the common man and check and restore the ecological degradation of Siwaliks through institutional developments status of the people.

9 Issue emerging from the watershed projects in siwaliks foothills

- More number of WHS are more beneficial than few big water harvesting dams.
- Landless communities are generally deprived of benefits particularly *Dalits*.

- The women folks are hardly involved in the projects whereas, their contribution in household management is tremendous.
- The VDC's should be regularly monitored and audited.
- Integrated multipronged approach in watershed management gave better results as seen from IWDP.
- Site specific technology for bioremedial measures and alternative land use evolved by SAU's yielded much more than traditional approach in reversing the ecological degradation of Siwaliks.

10 Conclusion

The Sukhomajri concept in Siwaliks has proved a successful model for sustainable development. The ecological degradation of the area have been checked as seen from siltation rate of Sukhana Lake. Food, fodder and fuel availability have proved the economic sustainability and replicability is shown by the growth of watershed management projects in geometric proportion. In net shell it can be stated that the model has developed its root network in Siwaliks in terms of social sustainability.In terms of future strategy special attention have to be paid to ensure the adequacy of social equity dimension with respect to caste, class, gender and ethnicity with potential programs for replicability in heterogeneous caste class situation.

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