Agricultural Economics Research Review
Vol. 24 July-December 2011 pp 225-233

Role of Watershed Management in Bridging Demand – Supply Gap of Fodder for Enhancing Livestock Production in Shivaliks, Haryana[§]

Swarn Lata Arya* , Pankaj Panwar and R.P. Yadav

Central Soil and Water Conservation Research and Training Institute, Research Centre, Chandigarh - 160 019

Abstract

Watershed programme is an important intervention in dryland areas to improve livestock productivity through increased feed and fodder supply. The present study has focused on the impact of watershed interventions on crop-livestock linkages with particular emphasis on how the interventions have affected the quantity of stovers/straws as livestock feeding materials in bridging the demand-supply gap. The study has been carried out in three typical Shivalik foothill watersheds (two treated and one untreated) in the Panchkula district of Haryana state. The impact of watershed development programme has been estimated by adopting both with and without approach and before and after approach. The untreated watershed has derived 65 per cent of its total income from animal husbandry. On the contrary, this sector has contributed 42 per cent and 20 per cent in two treated watersheds. The availability of supplemental irrigation enabled the villagers to step up cropping intensity. The number of goats has reduced considerably in both treated watersheds and the number of stall-fed buffaloes has increased. Adult cattle units per household and per hectatre of cultivated area have been found to be highest in the untreated watershed. Green and dry fodder availability, both from cultivated lands and forest area, has increased as a result of implementation of watershed programme. Although the gap between requirement and availability has narrowed down in both the treated watersheds, significant gains could be realized in Sambhalwa watershed due to sufficient water availability to all the households. Bunga watershed has also shown effectiveness of watershed development programme in reducing demand –supply gap of fodder. This gap, however, widened after reaching the saturation point of watershed programme, i.e. after 22 years of its implementation.

Key words: Fodder, Demand-supply gap, Watershed management, Livestock production, Shivaliks

JEL Classification: Q01, Q15, Q25, Q28

Introduction

Watershed development has been adopted as a key strategy by Government of India to develop rainfed-arid and semi-arid zones of the country. Various collaborative watershed development projects (WDPs) have been implemented in many states of India, involving government and NGOs as partners. These, in general, are believed to have brought out certain changes in livestock production systems also, involving shift in the existing system with low productive stocks to stall-fed systems with relatively high producing animals. Availability of higher quantity of forages from diversified land-use, improved use of common property resources and improved livestock management systems have enhanced the livestock productivity.

Though the importance of livestock in watershed management is generally recognized, there is a conspicuous absence of data and analysis on watershed

* Author for correspondence,
Email: swarn_arya@yahoo.com

§ The paper forms a part of the Institute Research Project entitled , "Study on Pastoral Migratory Graziers in relation to Watershed Projects in Shivalik Foothill Villages in Haryana" during the period 2004-2008.

management — livestock interaction at strategic, institutional as well as operational levels. As a matter of fact, livestock does not seem to be considered a priority in the relevant strategy papers. There are a number of studies that have looked at the impact of watershed programmes on rural livelihoods with a focus on crops and related activities, but few have considered the importance of livestock, its implications to rural livelihood and especially, feed and fodder availability and requirement (Birhtal and Taneja, 2006; Subrahmanyan *et al.,* 2006). Livestock production is an integral part of the farming system in the rainfed areas, especially in the ecologically fragile semi-arid watersheds (Puskur and Thorpe, 2005). Livestock plays a vital role in the economy of Shivalik foothill villages in Haryana state and is the primary source of livelihood contributing 50-65 per cent of the total income (Arya *et al.,* 1994; Arya and Samra, 2001; 2006).

Though livestock plays a significant role in the economy of the region, its productivity has remained low due to shortage of quality feed and fodder, mainly because of low productivity of grasslands and pastures (Vashist *et al.*, 2000) and small area under fodder cultivation (Katoch and Dogra, 1999). As per the draft report of the Working Group on Animal Husbandry and Dairying for the FiveYear-Plan 2002-2007, the current deficit is 63 Mt and 24 Mt for green and dry fodders, respectively (Planning Commission, 2001). The Watershed Development Projects undertaken by various agencies in the area have been addressing the issue of fodder deficit through increasing productivity and greater diversity. The present study focuses on the impact of watershed interventions on crop – livestock linkages, with particular emphasis on how the interventions have helped in bridging the demand-supply gap of fodder for livestock in Shivalik foothill villages of the Haryana state. The objective was also to examine the order of the gap between requirement and availability under various situations.

Data and Methodology

Study Area

The Shivalik foothill region, sandwiched between the Himalayas and the Indo-Gangetic alluvial plains (Mittal *et al.*,2000) is spread over an area of 3 Mha in the states of Punjab, Haryana, Himachal Pradesh and Jammu & Kashmir (Samra *et al.*, 1991)**.** It is estimated that 60 per cent of land in Shivaliks in Haryana is under agriculture, 30 per cent is under forest and 10 per cent is under miscellaneous uses (*Statistical Abstract of Haryana*, 2008-09). The farmlands are generally rainfed. Inadequate distribution of precipitation, poor soil fertility, erosion hazards and small landholdings have lowered farmland productivity to one-third of that in the irrigated areas (Yadav *et al.*, 2005).

An area of about 0.2 Mha of the Shivalik hills falls in the districts of Panchkula, Ambala and Yamunanagar of Haryana state and is ecologically highly imbalanced. In order to prevent and reverse the degradation process of Shivalik hills, Integrated Watershed Development (Hills) Projects had been implemented in different stages during the past three decades. These were aimed at providing a uniform integrated rural development platform to address the social and natural resources problems of the Shivalik area.

It is hypothesized that watershed development projects play a significant role in meeting fodder and water needs. However, it remains to be seen whether the changes brought about by the project continue to yield the fruits in long-term. The study has represented three types of situations, viz. (i) where no watershed programme has been implemented, (ii) village where watershed development project was implemented in 1997, and (iii) village where watershed programme was implemented twenty-five years ago in 1985, to see the long-term changes in the crop-livestock sector in terms of feed-fodder availability. The study has also examined as to how the interventions of watershed project at different time intervals have affected the demand-supply gap of feed and fodders under three different types of situations.

Data Collection

The study forms a part of the Institute Research Project undertaken at Central Soil and Water Conservation Research and Training Institute, Research Centre, Chandigarh. A three-stage sampling technique was used in the collection of data. The first stage involved the purposive selection of Panchkula district, based on the preponderance of Shivalik area (74.8%) out of three districts mentioned above. The second stage involved the selection of Dangri sub-watershed in the district where extensive watershed development activities were carried out under World Bank aided Integrated Watershed Development Project (IWDP).

Selection of villages was the third stage of sampling. The three villages chosen for the study provide a representative sample of the broad diversity of Shivalik foothill conditions and have varying degrees of production potential based on their bio-physical endowments and external linkages.

The village Bunga was treated with soil and water conservation measures in the year 1984-85, whereas, the village Sambhalwa was taken up for treatment in the year 1996-97 and Aasrewali village has not been treated and was taken as a control watershed. Bunga and Sambhalwa are the most successful watersheds in the region implemented at different time scales. Two earthen dams were constructed in Sambhalwa in 1996 and one in Bunga way back in 1984 to store runoff water from the adjoining hilly catchments and recycle it for agricultural production. The other component of the programme was the laying out of underground water conveyance system to provide supplemental irrigation to the rainfed agricultural lands. Hill Resource Management Societies in both the villages were constituted for catchments protection, water distribution, collection of water charges and maintenance of the pipe line system on day-to-day basis. One of the important functions of the Society was to persuade people to refrain from grazing their livestock, replace goats by buffaloes and substitute grazing by stall feeding with grass obtained from the forest area (Arya and Samra, 1995).

A complete enumeration of all the households in the selected villages was done in 2007-08 to collect data regarding area under various crops, irrigated area, fodder budgeting, income from various sources, animal population, etc. In fact, Bunga watershed was taken up in 1984-85 by the Research Centre in collaboration with Department of Agriculture, Haryana. The Centre has been monitoring the project activities as well as its impact on overall economy of the village at regular intervals since the inception of the project. The whole analysis with regard to fodder budgeting in case of Bunga watershed was carried out at three time intervals, viz. (i) in 1983-84, before the implementation of the project, (ii) in 1990-91, after six years of the implementation of the project, and (iii) in 2007-08, after 22 years of the project to see the sustainability of the impact. It was also intended to evaluate whether the Bunga watershed had outlived its projected life. Thus, the impact was estimated both by adopting with and without and before and after approach in the case of Bunga watershed.

Estimation of Forage Resources and Fodder Availability

Animal feed is available from cultivated as well as uncultivated lands. The uncultivated lands, as a source of feed, include cultivable and uncultivable waste lands, fallow lands, common lands, common pastures and grazing grounds and finally accessible forest areas. Further, only the accessible areas of uncultivated lands are, in fact, relevant for livestock production.

Feed available from the cultivated lands can be classified into (i) products and by-products of agriculture, and (ii) cultivated fodder. The availability of first component depends upon the quantum of agricultural production which in turn depends upon cropped area and yield of crops. Likewise, fodder from cultivated land depends upon the area allocated and the yield of fodder crops **(**Mishra and Sharma, 1990**).** Ultimately, availability of irrigation is the most decisive factor in the allocation of area to a particular crop as well as for increased output.

(i) Green Fodder

Estimation of green fodder availability was made from the resources like forage crops, grasses from forests, grazing lands, field bunds and weeds (harvested for fodder purpose) from cultivated fields. Fodder crop production was estimated on the basis of actual crop yields in the three watersheds. The area under fodder cultivation was taken on actual basis. In the case of forest, 50 per cent of the reported area was assumed as available for harvest of herbage (Tyagi and Shanker, 1995). The fodder from field bunds and field crops (weeds) were estimated by Participatory Rural Appraisal (PRA) technique and it was calculated by taking 10 per cent and 4 per cent of cultivated land, respectively. Total area available for fodder/grazing was calculated as sum total of forest area (50% of the reported), permanent pastures and grasslands, cultivated wasteland, barren and uncultivated land and area under bunds. It was observed through PRAs and key informant interviews that on an average, about 30 per cent of the grassland area is harvested as green fodder having production of about 5 t/ha and 2 t/ha in case of treated and untreated watersheds, respectively. The availability of grasses from forest areas was estimated on the basis of grass cutting measured on three slope positions in the watersheds, in 96 quadrants of 5×5m size (Samra and Singh, 1995).

(ii) Dry Fodder

The availability of dry fodder from crop residues was estimated on the basis of crop residual and grain-straw ratio. Dry fodder production from grasslands in the form of hay was calculated from 70 per cent of total grazing lands (Vashist *et al*., 2000; Singh, 1996; Tyagi and Shanker, 1995) at 1.5 t/ha dry fodder for treated watersheds and 0.7 t/ha for untreated watershed. The recommended fodder levels were used as the base for working out total requirements. Total dry matter requirement was computed @ 2.5 kg/100 kg live weight of live stock. Out of 2.5 kg of total dry matter, 2/3rd was to be fed as dry and 1/3rd as green roughage (Banerjee, 1997). The per cent gap between the requirement and availability was computed as:

$$\text{Per cent gap} = \frac{\text{Requirement of fodder} - \text{Availability of fodder}}{\text{Requirement of fodder}} \times 100$$

Conversion into Adult Cattle Unit

The livestock population of the village was converted into Adult Cattle Units (ACU) as per the conversion formula used by Tyagi and Shankar (1995) given as:

$$\text{No. of ACU} = \frac{\text{Animal weight} \times \text{No. of livestock}}{350}$$

1. Weight of cow (< 2.5 years of age) = 200 kg
2. Weight of cow (> 2.5 years of age) = 300 kg
3. Weight of buffalo (< 2.5 years of age) = 250 kg
4. Weight of buffalo (> 2.5 years of age) = 400 kg
5. Weight of sheep and goat = 1/5th ACU

Results and Discussion

Demographic Characteristics of Sample Villages

Two most important factors which determine the watershed potential to support livestock production are their resource endowment and management. The bio-physical livestock production potential is determined by a set of factors, which include the water availability, cropping intensity, vegetative cover, etc. Some general bio-physical and socio-economic characteristics of the studied watersheds which relate to and had a bearing on livestock production have been presented in Table 1.

Of the two treated watersheds, Sambhalwa reported higher irrigation intensity in comparison to Bunga due to the fact that Bunga was implemented much earlier in 1984-85 whereas Sambhalwa watershed project was taken up in 1996-97. The Bunga dam had lost more than half of its storage capacity due to siltation in the reservoir. Thus, only wheat crop is given supplemental irrigation. On the contrary, there is plenty of water available in two earthen dams in Sambhalwa watershed. The farmers are growing paddy, sugarcane and onion besides wheat and berseem. Of the two treated watersheds, agricultural sector contributed maximum, viz. 56 per cent towards total income in Sambhalwa, followed by animal husbandry (21%). In Bunga watershed, the share of animal husbandry sector to total income was 42 per cent, of which 9 per cent was from cattle migration . The income from animal husbandry sector in untreated watershed (Aasrewali) was 69 per cent, of which the share of cattle migration was 70 per cent. Due to acute shortage of water and fodder in Aasrewali, 56 per cent of households were found to migrate their cattle in search of greener pastures to the adjoining Punjab state for 6 to 8 months in a year. It further reaffirmed the findings that where water resources and agriculture have not developed significantly, cattle migration continues to be an alternative livelihood option due to lack of economic opportunities and overgrazing (Ramdas, 1996; Pradeep, 2001; Puskur and Thorpe, 2005).

Size and Composition of Livestock

Watershed development programme had a significant impact on the size and composition of livestock sector. Closure to grazing as a result of *Social Fencing* adopted by Hill Resource Management Society, initiated a slow but steady regeneration of the hills. The limited supply of water enabled the villagers to step up cropping intensity. Increased availability of fodder both from arable and non-arable lands, economic considerations, social compulsions and self-restraint brought out dramatic changes in the animal husbandry sector in the treated watersheds. The size and composition of animal population (cow, buffaloes, goats and bullocks) in studied watersheds have been given in Table 2. The number of Adult Cattle Units (buffalo equivalents) on per household and per hectare basis were 11.5 and 4.14, respectively in the Bunga watershed before the project implementation. Total

Table 1. Demographic characteristics of studied watersheds

Particulars	Untreated watershed	Treated watersheds	
	Aasrewali	Sambhalwa	Bunga
Total area (ha)	951	208	503
Forest and grazing lands (ha)	895	107	167
Cultivated area (ha)	89	101	336
Irrigated area (%)	Nil	100	43
Crops irrigated	Nil	Wheat, paddy, berseem, onion, sugarcane, sunflower	Wheat, berseem
Water applied (cm)	Nil	34.76	10
Irrigation intensity (%)	Nil	167	43
No. of households	69	81	176
Population	530	444	1062
Average family size	7.68	5.48	6.01
Average landholding	1.30	1.24	0.82
Percent households migrating cattle outside	56	nil	18
Percentage income from various sources			
a) Agriculture	8.47	55.81	25.09
b) Animal husbandry			
(i) within village	20.84	55.81	33.11
(ii) outside village from cattle migration	48.32	20.47	8.98
c) Service	6.91	0.00	24.57
d) Daily wages	9.81	5.51	5.93
e) Self-employment	5.65	4.42	2.32

Table 2. Size and composition of livestock in studied watersheds

Particulars	Untreated watershed	Treated watersheds		
	Aasrewali	Sambhalwa	Bunga	
	2007-08	2007-08	1983-84	1990-91	2007-08
Cows	1279	32	820	1205	703
Buffaloes	352	334	206	561	727
Goats	360	0	2174	652	51
Bullocks	69	118	140	186	37
Total livestock	2060	484	3340	2604	1518
Standard Livestock Units	1458	357	1391	1769	1333
Livestock intensity (ACU/ha)	16.38	3.53	4.14	5.26	3.97
Livestock intensity (ACU/household)	21.13	4.75	11.49	11.72	7.56

cattle population of the village Bunga was 2604 in 1991-92 as compared to 3340 before taking up the project, thus, recording a 28 per cent decline over a period of 8 years. The animal population further reduced by 42 per cent in 2007-08. Although the total number decreased after the project implementation, but when converted into standard livestock units, the cattle population showed 27 per cent increase after the project in 1990-91. This was due to change in the composition of animal population, which was worth noticing. There was considerable reduction in the number of goats due to complete protection from grazing by the village society after the implementation of the watershed management programme, which was very big

achievement in itself. The buffalo population increased by 253 per cent. Adult cattle units per household and per hectare of cultivated area were found to be the highest in the untreated watershed. On the contrary, it was the lowest in Sambhalwa, i.e. the recently treated watershed.

Fodder Availability from Various Sources

Fodder production and its utilization depend on the cropping pattern, climate, irrigation intensity, socio-economic conditions and type of livestock**.** The forage and fodder availability from different land resources has been presented in Table 3. In the village Aasrewali (untreated watershed), harvested grasses from forest and common grazing lands (both dry as well as green) had been the chief fodder sources for livestock . Green and dry fodder availability from cultivated lands contributed more than 65 per cent to the total green and dry fodder production in treated watersheds due to the availability of irrigation and maximum area under cultivation in both the villages. Only 9 per cent of the total area of the village Aasrewali was reported to be under cultivation thereby contributing only 33 per cent to the total green fodder production.

The study revealed that there was a drastic change in the area under cultivation and the type of crop with the implementation of watershed project. The crops which required less amount of water were cultivated more prior to project implementation in Bunga watershed, these were maize, jowar fodder, bajra and groundnut in the *khraif* and pulses like gram and arhar in the *rabi* season. With the availability of water after the implementation of the project, the area under these crops reduced drastically and was replaced by water-demanding crops like sugarcane and paddy, besides maize in the *kharif* season. In *rabi* season, about 59 per cent of the area was under pulses in 1982-83, which reduced to 1 per cent in 2006-07. The area under wheat increased from 37 to 73 per cent and berseem from nil to 6 per cent. During the survey conducted in 2007-08, it was reported that more than half of the storage capacity of water harvesting reservoir had been lost due to siltation from the catchment area. Consequently, water availability to the crops also reduced.

The whole cultivated area was receiving irrigation in the Sambhalwa watershed. Paddy crop occupied 68 per cent of area, followed by jowar fodder (29%), maize (9%), sugarcane (1%) and lentil (0.4%) in *kharif* season. During *rabi*, wheat was grown on 72 per cent of cultivated area, followed by berseem (10%), sunflower (9%), onion (8%) and sugarcane (1%). Contrary to this, only maize and jowar in the *kharif* season and wheat and taramira in the *rabi* season were

Table 3. Annual fodder availability from various sources in studied villages

(tonne)

Particulars	Untreated watershed	Treated watersheds			
	Aasrewali	Sambhalwa	Bunga		
	2007-08	2007-08	1983-84	1990-91	2007-08
Green fodder production					
From forest and grazing lands	671	82	125	250	290
	(58.15)	(5.78)	(6.78)	(5.88)	(14.44)
Weeds from cultivated area	102	280	390	445	385
	(8.84)	(19.75)	(21.15)	(10.48)	(19.18)
Cultivated fodder	381	1056	1329	3551	1332
	(33.01)	(74.47)	(72.07)	(83.63)	(66.36)
Total	1154	1418	1844	4246	2007
Dry fodder production					
From fields (crop residues)	140	604	994	1552	941
	(22.95)	(91.10)	(91.95)	(85.60)	(78.09)
From forest and grazing lands	470	59	87	261	264
	(77.05)	(8.90)	(8.05)	(14.40)	(21.91)
Total	610	663	1081	1813	1205

Note: Figures within the parentheses denote percentage contribution to the total.

being cultivated in the untreated watershed (Aasrewali).

Fodder Supply-Demand Balance Sheet

Watershed Development Programmes aim at improvements in the farming systems through investments in soil and water conservation and natural resource management in the rainfed areas. Table 4 revealed the pattern in both treated as well as non-treated watersheds with respect to fodder requirement and availability. Annual budgeting for green and dry fodder in Bunga and Sambhalwa (treated) and Aasrewali (untreated) watersheds was done to work out the carrying capacity in terms of Adult Cattle Units (ACUs). It was revealed that except Sambhalwa, the other two villages were supporting more than double ACUs in comparison to their carrying capacity in terms of fodder production from agricultural fields and forest area. The gap between demand and supply of green and dry fodder in untreated watershed was to the tune of 70 and 80 per cent, respectively whereas in the case of Sambhalwa (treated watershed), the supply of total fodder exceeded the existing demand .

In the case of Bunga watershed, since the data was available for all the years due to continuous monitoring, the situation was compared within the watershed over three periods of time to see the changes over a long period. Respite from grazing and excessive cutting of vegetation increased forage grass production from the hills and cultivated lands in 1990-91 over 1983-84 but the availability of total dry matter still fell short by 39 per cent due to change in the composition of animal population. This gap was accentuated in 2007-08 due to the decline in both green as well as dry fodder production from cultivated area. This happened because of reduction in (i) area receiving supplemental irrigation, (ii) intensity of irrigation, and (iii) increase in the number of buffaloes. Apparently, the project has outlived its projected life of 20 years. After 25 years of its implementation, the earthen dam needs to be de-silted which, till date, has not been done. However, the height of the dam has been raised twice by one metre. Thus, the order of the gap between requirement and availability, although bridged by watershed interventions, increased over a period of time in the Bunga watershed.

Conclusions

The most crucial input to livestock health and production is the quantity and quality of feeds and fodders to animals. Animal feed availability is dependent on agricultural production and its composition, area allocated to fodder crops and its yield, and finally on accessible uncultivated land including grass land and forests. There has been substantial gains in terms of increased fodder availabilities both from fields and forests in the treated successful watershed villages. Grazing has been totally eliminated in the forest areas as the villagers themselves have been protecting the hills by making Hill Resource Managing Societies. The watershed management programme has prompted people to change their livestock composition significantly in favour of stall-fed buffaloes. The most effective achievement of the programme has been the reduction in the number of goats. Of the two treated watersheds, substantial gains in crop-livestock sector could be realized in Sambhalwa due to sufficient water availability to all the households.

Table 4. Annual budgeting for green and dry fodder and livestock carrying capacity in Bunga watershed

Village/watershed	Green fodder* (tonnes)			Dry fodder (tonnes)			Total fodder (tonnes)			Adult Cattle Unit (ACUs)	
	Requi-rement	Avail-ability	Gap (%)	Requi-rement	Avail-ability	Gap (%)	Requi-rement	Avail-ability	Gap (%)	Actual	Carrying capacity
Aasrewali 2007-08	1537	462	-69.94	3120	610	-80.44	4657	1072	-76.98	1458	336
Sambhalwa 2007-08	380	567	+28.46	760	663	-12.76	1140	1230	+7.31	385	357
Bunga 1983-84	1481	738	-50.16	2962	1081	-63.50	4443	1819	-59.05	1391	570
Bunga 1990-91	1883	1618	-14.07	3766	1813	-51.85	5649	3431	-39.26	1769	1075
Bunga 2007-08	1419	802	-43.48	2838	1205	-57.54	4257	2007	-52.85	1331	660

Notes: *Green fodder has been converted into 40% dry matter
A (-) value denotes requirement exceeds availability and vice-versa

Significant changes in livestock sector as a whole can be achieved only when there has been a substantial increase in irrigation intensity as was the case of Sambhalwa village. It means that availability of irrigation is central to increased cropping intensity, crop and fodder productivity and forage resources availability from common forest lands. The study by Chopra and Gulati (2001), Shah (2001) and Deshingkar and Start (2003) have also highlighted that irrigation intensity and regeneration of forests have direct impact on strengthening the crop –livestock linkages. There is also a need to explore a large part of the available water as common pool resources and thereby expand its net of beneficiaries. At the same time, emphasis should be on efficient use of resources on private lands (Birthal *et al.,* 2005). Successful watershed village has lowered gap in the availability of fodder and demand for livestock which is a major source of livelihood for small and marginal farmers. Long-term study in Bunga has shown effectiveness of watershed development programme in reducing the gap in demand and supply of livestock fodder. The gap, however, widened after reaching the saturation point of watershed interventions. The Bunga watershed has reached its saturation level after a period of 20 years. The reservoir needs to be de-silted and renovated to revive its rainwater storage capacity. The history of ponds and *'johars'* in India shows that desiltation was a regular activity undertaken by the local communities. Unfortunately, such a tradition has slowly died down.

Acknowledgement

The authors very sincerely thank the referee for his valuable and crucial comments which have been of considerable help in improving the presentation of the paper**.**

References

Arya, Swarn Lata, Agnihotri, Y. and Samra, J.S. (1994) Watershed management induced changes in animal population structure, income and cattle migration in Shiwaliks. *Ambio, Journal of Royal Swedish Academy of Science*, **23**(7):446-450.

Arya, Swarn Lata and Samra, J.S. (1995) *Socio Economic Implications and Participatory Integrated Appraisal of Integrated Watershed Management Project at Bunga.* Bulletin No.T-27/C-6, Central Soil and Water Conservation Research and Training Institute, Research Centre, Chandigarh. 112 p

Arya, Swarn Lata and Samra, J. S. (2001) Re-*visiting Watershed Management Institutuions in Haryana Shiwaliks, India.* Central Soil and Water Conservation Research and Training Institute, Research Centre, Chandigarh. 360 p.

Arya, Swarn Lata and Samra, J. S. (2006) Impact analysis of watershed development projects in Shiwalik foothill villages in Haryana state. *Agricultural Situation in India,* **62**(2):711-722.

Banerjee, G.C. (1997) *A Textbook of Animal Husbandry*. Oxford and IBH Publishing Co., New Delhi. 854 p.

Birthal, P.S. and Taneja, V.K. (2006) Livestock sector in India: Opportunities and challenges for smallholders, *Proceedings of ICAR-ILRI International Workshop*. National Centre for Agricultural Economics and Policy Research, New Delhi, 117p.

Birthal, P.S., Mishra, S.N, Dixit, A.K. and Tripathi, G. (2005) *India's Livestock Feed Balance and its Environmental Implications*. Project Report. National Centre for Agricultural Economics and Policy Research, New Delhi.

Chopra, Kanchan and Gulati, S. C. (2001) *Migration, CPRs and Environmental Degrdation: Interlinkages in India's Arid and Semi-Arid Regions.* Sage Publications, New Delhi.

Deshingkar, P. and Start, D. (2003) *Seasonal Migration for Livelihoods, Coping, Accumulation and Exclusion.* Working Paper No. 220. Overseas Development Institute, London.

Katoch, B.S. and Dogra, K.K (1999) *Present Scenario and Strategies for Improving the Nutritional Status and Carrying Capacity of the Natural Grasslands/Pastures of Himachal Pradesh. A Report.* Department of Animal Nutrition, College of Veterinery and Animal Sciencies. CSKHPKV Palampur, Himachal Pradesh. 11 p.

Mishra, S.N. and Sharma, R. (1990) *Livestock Development in India — An Appraisal*. Vikas Publishing House Pvt Ltd, New Delhi. 53 p.

Mittal, S.P., Aggarwal, R.K. and Samra, J.S. (2000) *Fifty Years of Research on Sustainable Resource Management in Shiwaliks.* Central Soil and Water Consevation Research and Training Institute, Research Centre, Chandigarh, 506 p.

Planning Commission, Government of India (2001) *Draft Report on the Working Group on Animal Husbandry and Dairying for Five Year Plan* (2002-2007), New Delhi.

Pradeep, T. (2001) *Environment-Mixed Farming: Eco-restoration-Livestock Development-Household Food Security*. Watershed Development Programmes.

Ramdas Sagari, R. (1996) *An Appraisal of Livestock Production Systems in Watershed Development Project Areas of Inter Co-operation — NGO Partners, Chittor District, A.P.* Unpublished Report.

Puskur, Ranjitha and Thorpe, William (2005) Crop and non-crop productivity gains: Livestock in water scarce watersheds In: *Watershed Management Challenges, Improving Productivity, Resources and Livelihoods*, Eds: Bharat R. Sharma, J.S. Samra, C.A. Scott and Suhas P. Wani. Department of Agriculture & Cooperation, Ministry of Agriculture, Government of India, New Delhi.

Samra, J.S., Grewal, S.S., Bansal, R.C, Mittal, S.P, Agnihotri, Y, Goel, P.K, Sashtri, G. and Singh, G. (1991) *Management Plan for Environmental Rehabilitation of Degraded Shiwaliks through Watershed Management*. Central Soil and Water Conservation Research and Training Institute, Research Centre, Chandigarh.

Samra, J.S. and Singh, S.C. (1995) Comparison of soil properties: Tree basal area and above ground biomass of grasses and shrubs at three topographic positions of a restored watershed. *Indian Journal of Soil Conservation*, **23**(3):175-184.

Shah, Amita (2001) Water scarcity induced migration: How far watershed projects can help. *Economic and Political Weekly*, **36**(35): 3405-3410.

Singh, Punjab (1996) Status of Himalayan rangelands in India and their sustainable management. In: *Proc. Rangelands and Pastoral Development in Hindu Kush-Himalayas*, Eds: Daniel J Miller and Sienna R. Craig, pp. 13-22.

Statistical Abstract of Haryana (2008-09) Economic and Statistical Organisation, Government of Haryana.

Subrahmanyam, S., Bezkorowajnyj, Peter, Shiferaw Bekele, Wani, S.P., Parthasarathy Rao, P. and Nageswara Rao, G.D. (2006) *Crop-Livestock Linkages in Watersheds of Andhra Pradesh. Global Theme on Agroecosystems* Report No. 29. International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh. 52 p.

Tyagi, R. K. and Shankar, Vinod (1995) Forage supply-demand analysis for Saurashtra and Kachchh. *Forage Research*, **16**(2): 45-57.

Vashist, G.D., Mehta, P. , Kumar, A. , Sharma, S.K. and Katoch, D.C. (2000) *A Study of Socio-economic Aspects of Forage and Fodder Crops — A Case Study of Availability and Requirement in Himachal Pradesh.* Department of Agricultural Economics, CSK HPKV, Palampur. 121 p.

Yadav, R.P., Aggarwal, R.K., Arya, Swarn Lata, Singh, P., Prasad, R., Bhattacharyya, P., Tiwari, A.K. and Yadav, M.K. (2005) *Rainwater Harvesting and Recycling Technology for Sustainable Production in Small Agricultural Watershed- Johranpur.* Bulletin Nos. T-50/C- 11, Central Soil and Water Conservation Research and Training Institute, Research Centre, Chandigarh, 201 p.

Received: November 2010; Accepted: April 2011