ACTA SCIENTIFIC AGRICULTURE (ISSN: 2581-365X)

Volume 3 Issue 5 May 2019

Research Article

Resource Use Efficiency and Farm Productivity Gap of Smallholder Farmers in Belbari and Jante VDCS of Morang

K Adhikari[1]*, LP Amgain[1], N Bastakoti[2] and P Regmi[3]

[1]*Institute of Agriculture and Animal Science, Tribhuwan University, Lamjung Campus, Nepal*

[2]*United Mission in Nepal, Kathmandu, Nepal*

[3]*Agriculture and Forestry University, Rampur, Chitwan, Nepal*

***Corresponding Author:** K Adhikari, Institute of Agriculture and Animal Science, Tribhuwan University, Lamjung Campus, Nepal.

Received: February 12, 2019; **Published:** April 15, 2019

Abstract

A farm level study was conducted for identification of resource endowment, ecological and economic performance of mixed farms of former Belbari and Jante VDCs of Morang district, Nepal. The farm performance was observed using DEED (Describe, Explain, Evaluate and Design) framework wherein the study focused mainly on soil organic carbon content and nutrient dynamics (especially Nitrogen dynamics). The corresponding farm level survey was done by visiting four selected farm of two communities, based on total land area, farming system and internal and external resources in farm and was followed by soil analysis of soil samples in ATC, Lalitpur and Soil Management Directorate, Hariharbhawan. Study revealed that farming was the major source of livelihood of the people and the components of farming system comprised of crops and livestock and access to different natural resources. The soil analysis report showed that the SOM content of farms at Belbari VDC were lower (0.15% and 0.11%), while it was higher in Jante VDC (0.08% and 0.34%). The report also showed that the nitrogen content in the farms of Jante were higher (0.24% and 0.21%) while it was low in Belbari (0.16% and 0.18%). The study suggests that the farm ecological and economic performance can be widened by appropriate soil management practices. The productivity of mixed farms can be increased by including green manure crops in cropping system and sustainability of farm can be ensured by increasing soil organic carbon content. Improved soil and manure management practices can minimize the soil nutrient loss and increase nutrient availability to the crops which increases the farm production performances.

Keywords: DEED; Farm Design; Productivity; Sustainable Yield

Introduction

Agriculture is one of the most important sectors in Nepal. About two-thirds of the country's population is dependent on agriculture for their subsistence and the agriculture sector constitutes more than a third of gross domestic product (GDP) [1]. The majority of Nepalese farmers are subsistence with mixed/integrated farms and relatively small (0.66 ha) land holdings (Agriculture census (CBS), 2011/12) [2]. Ensuring effective agriculture production across the country has been a serious challenge due to the high degree of spatial and temporal climate variability, irrigated, and rainfed agriculture systems, coupled with farmers' fragile social and economic situations and unique mountain agricultural practices. Despite government's endeavors to launch development activities launched, the country's agricultural sector has been unable to reach the expected level but remained rather stagnant, even resulting in a decline in agriculture productivity [3]. In Nepalese agriculture, resource degradation is a major problem for sustainability of farming system in the mountains and hills. The notion of sustainability would not attract or motivate farmers unless productivity concerns are adequately addressed [4]. Soil degradation is severe, especially in the hilly regions (Chalise and Khanal, 1997 as cited in Bastakoti., *et al.* 2011) but in Terai the effect is lower. Annual average temperature of Morang was 24.9ºC and annual average rainfall recorded was 133.1 mm which has an erotic distribution all around the year [5]. This study focuses on the farming system performed on terai, which is a

location-specific, environment-adaptive system, subsistence and semi-subsistence, complex and intensive cropping system. The subsistence farming system has been changing toward higher productivity in recent years, in order to meet the increasing demand for food due to expanding population. A typical definition of farming system is, "a unique and reasonably stable arrangement of farming enterprises that the households manage according to well defined practices in response to physical, biological and socioeconomic environments and in accordance with households' goals, preferences and resources" [6]. Farming system in terai has distinctive characteristics that the farming is largely based on interactions among three major components: crops, livestock and forestry (only in few cases). Crops provide feed and fodder to animals, which in return supply draft power and manure, and forests give nutrients and support lands. Hence, this study also examines the environmental soundness and social acceptability in the two villages of Morang district in Nepal. The environmental soundness here refers to the conservation and improvements of natural resources and environment; the social acceptability refers to the quality of life of the farmers in two study villages.

Materials and Methods

The study was carried out in two VDCs of Morang i.e. Belbari and Jante wherein 4 mixed farm, two from each VDCs were interviewed which in turn was followed by soil sampling and analysis. Primary data was collected at the household level wherein a general soil survey and secondary data was collected from related institutions (Government and Non-governmental documents), books and publications. Most of the data requirement for modeling using Farm DESIGN was measured in field and laboratory analysis. Some data were taken from other sources. The information collected were first tabulated and entered into MS-excel sheet. The Farm DESIGN model Version-4.16.0 was employed for modeling carbon and nutrient flows, labor use and farm income. After generating the scenario(s), Farm DESIGN was used to check the results of the options to enhance system performance of the farms based on model analysis.

Result and Discussion

Farm characteristics and resource endowments

The two distinct communities - Belbari and Jante, have similar climatic and topographic characteristics and in both areas most farms are mixed farms. Farms were typically rather small and farm acreage ranged from 0.3 to 0.7 ha. The average number of livestock per household was 5.5 across the study farms and average livestock density was 5.3/ha in Belbari and 25.5/ha in Jante VDC. In Belbari, farmers were applying on average 92, 145, 92 and 16000 Kg of urea, Di-ammonium phosphate (DAP), and FYM per hectare annually, respectively and in Jante, farmers were applying 102 kg urea, 64 kg DAP, 10 kg potash and 29500 kg of FYM per hectare of land annually. The average FYM use was 84% higher than in Belbari.

Characteristics	Belbari	Jante
No. of farm surveyed	2	2
Average Land holding (ha)	0.47	0.33
Average no. of livestock	3	8
Livestock Density (no./ha)	5.3	25.3
Urea (kg/ha/year)	94	102
DAP (kg/ha/year)	145	64
MOP (kg/ha/year)	92	10
FYM (Mt./ha/year)	16	29.5

Table 1: *Characteristics of households being sampled.*

Resource use at community level

Land holding was not equal in terms of farm size distribution and had high intrinsic variation at both study sites. The smaller farms had higher animal densities which in turn increase crop production. In Belbari, the farms had greater land holdings (0.48 ha average) compared to the Jante farms (0.33 ha average), while for the total livestock number per ha per households the reverse was true and it appears that small farms tended to keep more animals. Crop residues, crop by-products, and forages derived from field areas are also contributing to the overall dry matter (DM) requirements for feeding the livestock. The farms were commonly using Elephant grasses (*Pennisetum purpureum*), *Digitaria decumbens*, maize grass and weeds growing in the field and *Cyanodon dactylon* around the farm border.

Due to small land holding farmers were getting less forage production from their own land but since they had higher livestock densities these farms were more dependent on external resources for livestock feed. The communal land were contributing about 30 percent of the total organic carbon in the form animal feed, and the

variation in contribution between the farms was influenced by the farm size and livestock density. This refers that the farmers in both the community were maintaining on farm soil fertility and the soil carbon content to sustain their livelihood by the use of locally available resources. Thus, there exist a vast interaction between the use of organic amendment and higher animal density in both the farm under study.

SOC and N budgets at community level

In Belbari VDCs, values for only N balances was positive and P and K balance were negative except on the B1 farm for K balance. Similarly, the N, P and K balance were negative for the farms of Jante VDC. On the other hand, the SOM balance was more positive (average 355 Kg ha^{-1}) in the farm of Jante as compared to the t farms of Belbari (average 182 Kg ha^{-1}). Different technical intervention of the NGOs acting on both the community acts as the evidence for the observed differences in the soil N and SOC for the improved management of local farm resources. The farmers were not clear about the effect of using undecomposed FYM and no any measures were adopted to protect the FYM from the sunlight and water. They were applying the FYM along with the litter in the form of heap scattered in different place in the field mostly during summer ploughing/ primary harrowing of field before cultivation of each crops. This unsafe collection method of FYM is more responsible for the loss of nutrient especially nitrogen and potash through volatilization and leaching. Covering the manures either by thatch/tin/slate or by plastic sheets is supposed to increase nutrient retention and reduce nutrient losses. This practice increases soil nutrient (N, P and K) which in turn can hike crop yields for maize and upland rice [7]. As cited in Katyal [8] and Sanchez (1976) 60% - 80% of phosphorous in soil is in organic form.

Farm Code	OM	N	P	K
B1	173	83	-24	8
B2	191	12	-101	-61
J1	405	-15	-40	-19
J2	354	-55	-13	-42

Table 2: Nutrients and OM balance for all four farms of Belbari and Jante VDC (Kg ha^{-1}).

[1]B1: Shiva Kumar Ghimire; B2: Dipak Khulal; J1: Yamnath Khatiwada; J2: Bishnu Prasad Khatiwada.

In Jante, the combined nitrogen losses due to leaching and volatilization in farm J1 and J2 were 28 kg/ha and 55 kg/ha respectively. Similarly, this statistic in B1 and B2 farms of Belbari VDC, 22 kg/ha and 71 kg/ha. Among the four farms, N losses was lower in Farm B1 of Belbari VDC. The imbalance of feed and no optimum utilization of local feed resources cause lower animal efficiency for N utilization.

Resource use at the farm level

The land holding of farm B1 and B2 was 0.3 ha and 0.63 ha respectively whereas of farm J1 and J2 was 0.33 ha and 0.33 ha. The total area of land was irrigated and soil was loamy under test. In both the communities the lands were allocated to produce of rice, maize, mustard and vegetables. The difference is that in Belbari farm (B1 and B2) farmers primarily focused on production of vegetables rather than food crops. All the farms were using parts of their own products (Rice, Maize) for feeding animals in addition to concentrates. Crop residues, crop by-products, and forages derived from communal range land areas were also contributing to the overall dry matter (DM) requirements for feeding or grazing livestock.

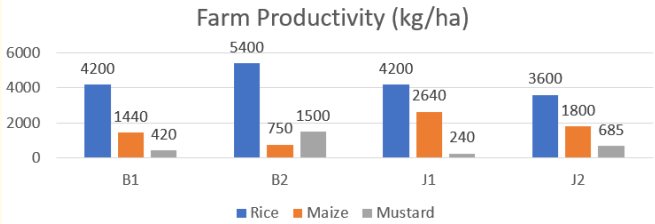

Figure 1: Productivity (in Kg/ha) of major crops for each of the selected farms

The farm analysis gives the result that farmers were harvesting the bulk of feed resources during a specific period of time in a year. All the feeds are in higher fiber content and such diet may increase CH_4 emission compared to concentrate feeding [9]. The farmers were more depend on the feed resources locally available in the farms and some communal resources. Study revealed that although there was the availability of forest resources for the collection of feed resources like fodder, forage and pastures but the people were reluctant to use it due to less feasibility due to time and resource problem. The average animal density was higher (5.3/ha) in Belbari than in Jante VDC (25.5/ha). This implies that the farmers at Jante VDC were exploiting the resources more than

in Belbari VDC as higher animal density, FYM/compost application, coincided with higher soil nutrient test results, especially for SOC. An overview of the overall feed balance situation for the selected farms calculated with the Farm DESIGN model is presented in table 3. All feed values were calculated based on the feed saturation value of all feed stuffs. It appears that in most cases forage supply is covering animal requirements.

Farm Code	DM intake	Energy	Protein
B1	786.7	1343	43.2
B2	24.8	-87.6	-87.8
J1	-32.3	-96.6	-99.2
J2	-36.5	-92.1	-99.4

Table 3: Dry matter intake, energy and protein balances for improved vs traditional farms at the Belbari and Jante VDCs, expressed as a percentage deviation from the animal requirement.

SOM-C and N budget at farm level

The negative nutrient balance is the main cause for decreased production of farm in both the community that indicates the inherent capacity of soil to supply nutrient i.e. soil fertility is declining day by day. The farms in Jante VDC, was featured with high animal density that produces more FYM on the farm than on the farms of Belbari VDC. Higher application of FYM or compost might have caused high accumulation of OM in farm J1. The application of FYM during 7 year of a pearl-millet-wheat cropping sequence was shown to improve the SOC, total N, P and K status (Kaur., *et al.* 2005). Moreover, Stolze., *et al.* 2000 and Alföldi., *et al.* 2002, cited in Davis and Abbott, 2006 also documented that under tropical country SOM mineralization and decomposition is faster than in temperate region.

Farm Code	Farm N Efficiency (%)	Animal N efficiency (%)	Soil N loss	Total N Input	Total N output	Balance
B1	36	3	22	130	47	83
B2	86	0	71	85	73	12
J1	130	10	34	48	63	-15
J2	265	20	56	31	82	-51

Table 4: Nitrogen use efficiency, N-losses and N balance for all 4 farms.

Economic performance

The gross margins in four farms varied as did the contributions from crop and animal-based activities. In Belbari VDC, the total gross margin (Rs. 283412) was higher in farm (B2) and this farm also had a higher margin from animals (Rs. 82973) and crops (Rs. 200439). The corresponding values for farm B1 were Rs. 112618, Rs. 28452 and Rs. 84166, respectively. In Jante VDC, the farm J1 total gross margin and gross margin from crop and animal production were Rs. 397349, Rs. 76980 and Rs. 320369 respectively. The corresponding values for farm J2 were Rs. 181671, Rs. 64300 and Rs. 117371, respectively. Agricultural practices affects the soil fertility which is responsible for environmental and economic sustainability of all farming systems (Davis and Abbott, 2006). The statistics in table shows that the majority of production cost was accounted for labour in all the farms. The loss of nutrient i.e. N, P and K of the soil reflects the increased economic performance of the farms. The sustainable soil management practices can increase the farm economic performance. In actual the return for the family labor is less than what they would receive from working outside in other farm and based on excess supply of family labor it may be possible that part of the family income is derived from other activities and remittances [10,11].

Farm Code	GM[1] crops	GM animals	Total margin	Total labour cost	Total Cost	Total Profit	LB[2] (hrs)
B1	84166	28452	112618	30926	34316	78302	-825
B2	200439	82973	283412	59608	79608	203804	-1590
J1	76980	320369	397349	38786	49594	347756	-1034
J2	64300	117371	181671	34969	52544	129127	-933

Table 5: Cost benefit analysis results from Farm DESIGN (in Rs.)/ Farms.

1: Gm = Gross margin, (includes home consumption and products sold at farm).

2: LB= labor balance (negative balance indicates labor surplus at farm.

Conclusions and Recommendations

The study concludes that agriculture is the major source to sustain the life of the villages of the eastern Terai belt of Nepal. The farmers had less land ownership and the land available is also fragmented in small parcel. The mixed farming system practice in small land holding lead a way to more extensive exploitation of local resource decreasing the productivity of the farm. In both the VDCs family labor is at most for running the farm and only in peak season the casual labour are hired. The farm in Belbari community makes relatively higher use of chemicals fertilizers like Urea, DAP and Potash may be because of more vegetable based cropping system than the farm of Jante that has higher application of FYM/ compost on the farm due to higher animal densities. The mixed farming system practice in small land holding lead a way to more extensive exploitation of local resource decreasing the productivity of the farm. In both the VDCs family labor is at most for running the farm and only in peak season the casual labour are hired. The farm in Belbari community makes relatively higher use of chemicals fertilizers like Urea, DAP and Potash may be because of more vegetable based cropping system than the farm of Jante that has higher application of FYM/compost on the farm due to higher animal densities. Based on soil analysis at the field level and input resources used at the individual farm level it is seen that the farms of Jante VDC has higher soil organic carbon and N levels which appears to be related to proper management of farm resource inputs and maximized application of FYM/compost which can further be related with the higher animal densities of the farm. Likewise, high N efficiency in farms is proportional to better economic performance of farms. Thus, the fact that the farms are exploiting the land resource and neglecting the measures to optimize the nutrient content of available FYM, the farm management decision strategies are to be further corrected to hike the overall farm return and sustain farm in profitable way. The next important step will be the use of Farm DESIGN model to explore the alternatives for farm management practices. Moreover, this study has also clearly demonstrated that the choice of FYM/ compost to the chemical fertilizer is a wise decision for sustainable management of the farm increasing the nutrient efficiency and farm efficiency as a whole. Similarly, for better tuning of the farm performance several steps to increase the SOM content and preventive measures against the degradation of FYM quality in terms of nutrient quality would be a logical decision. Therefore, the farmers prioritizing the application of FYM/compost than chemical fertilizer helps to sustain the fertility of soil that correspond to the increased productivity of crops and greater farm return.

Bibliography

1. International Centre for Integrated Mountain Development ICIMOD Publications Unit (2015).
2. Central Bureau of Statistics. Statistical Year Book of Nepal 2007. NPC. HMG/N. Kathmandu. Nepal (2007).
3. Regmi PP. "Agricultural Development through Eco-Restructuring in Different Ecological Zones across Nepal". Ph. D Thesis. Asian Institute of Technology. School of Environment, Resources and Development, Thailand (1999).
4. Palikhe A. "Sustainable development of farming system in the mid-hills of Nepal". A Dissertation Submitted in Partial Fulfillment of The Requirements for the Degree of Doctor of Philosophy in International Bio-Business Studies. Graduate School of Agriculture, Tokyo University of Agriculture (2010).
5. District Agriculture Development Office Annual Report (2015).
6. Shaner WW., *et al*. "Farming Systems Research and Development: Guidelines for Developing Countries". Westview Press, Boulder (1982).
7. Triphati BP and J Ellis-Jones. "Improving manure quality and its use in maize and upland 52 rice production in the hills of western Nepal". In: Joshi B.K., S. L. Joshi and K. P. Paudyal (Eds.). Agricultural Research for Enhancing livelihood of Nepalese People. Proceeding of 2nd SAS-N Convention, 30 July-1 August 2003, Kathmandu (2004).
8. Katyal JCN., *et al*. "Critical aspects of organic matter management in the Tropics: the example of India". *Journal of Nutrient Cycling in Agroecosystems* 61.1-2 (2001): 77-88.
9. Aluwong T., *et al*. "Livestock-environment interactions: methane emissions from ruminants". *African Journal of Biotechnology* 10.8 (2001): 1265-1269.
10. Food and Agriculture Organization. "Nepal Agricultural Policy and Strategies for Poverty Alleviation and Food Security". Main Report, FAO. Kathmandu, Nepal (2003).

11. Weber G. "Compilation of baseline information for integrated plant nutrient management in Mid-hill farming system of Nepal (version 2)". SSM-P Document 89. Sustainable Soil Management Program, Helvetas, Lalitpur Nepal (2003): 15-25.

Volume 3 Issue 5 May 2019