Spatial Distribution of Farm-Family Resources in the Mid-Hills of Nepal

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ABSTRACT

The location of farm households along the spatial gradient affects resource availability and farmers' livelihoods. Many socioeconomic variables have strong spatial affinity that would otherwise be overlooked by data aggregation at household levels. The Geographic Information System (GIS) displays and analyzes socioeconomic data that could aid many social researchers in understanding socioeconomic reality influenced by geographical positions. This paper aims to integrate socioeconomic data into a GIS environment. It examines spatial tendencies of farm-family resources in the mid-hills of Nepal using spatial and random sampling techniques. Farmers living in relatively flat lands and nearby urban centers have small families, higher level of education, farm and family income. In addition, they have small agricultural holdings and engage in commercial farming. Meanwhile, the opposite applies to farmers living in the hills. These spatial differences are related mainly to road, market, and other infrastructure that are crucial for agricultural development and livelihood enhancement. Strong spatial trend in socioeconomic aspects and farm-family resource availability infer the need to focus development activities spatially.

INTRODUCTION

The variations in resource availability and socioeconomic attributes of farm households in the small transects of Nepal's mid-hill regions are due mainly to topographical differences, population density, market demand, and availability of infrastructure (Bhatta 2010; Bhatta and Doppler 2010). Land use is extremely diverse primarily because farm-family resources are available (Bhatta 2010). Consequently, farm methodologies along the spatial gradient vary (Bhatta and Lynch 2011). Farmers in higher altitudes mostly engage in subsistence farming. However, in recent decades, market-oriented production has emerged as a key driving force in land use intensification in the densely populated flat lands, particularly in urban and peri-urban areas (Brown and Shrestha 2000).

In the spatial realm, subsistence farming is dominant in rural areas that are 20-30 kilometers (km) away from the Kathmandu Valley. Many resource-poor farmers in the rural hills apply traditional systems chiefly for subsistence production (Scialabba 2000). This spatial differentiation would give birth to different farming practices (Bhatta and Neupane 2010; Bhatta et al. 2009), thereby producing different socioeconomic attributes in farm families (Bhatta and Doppler 2010).

This research is based on the concept of spatial effects on farm-family resources and socioeconomic attributes. Such effects are determined by integrating socioeconomic data in a Geographic Information System (GIS) environment and evaluating the said aspects spatially. Farm families manage local resources whose biophysical characteristics are principally governed by their spatial position of farm households (K.C. 2005). Socioeconomic differentiation arises owing to the distances between fields, markets, access to information, credit facilities, and locations of off-farm opportunities (Bhatta and Doppler 2011; Bhatta 2010; K.C. 2005; Brown 2003). The surrounding environment also influences farm-family resource availability and use (K.C. 2005). Hence, both biophysical settings of resources and the socioeconomic characteristics of farm families can be influenced by their spatial position. Location-specific information for an entire region is best handled by a computerized information system such as GIS. GIS software provide tools for the display and analysis of spatial information (Starr and Estes 1990). It stores geographic data, retrieves and combines the data to create a new representation of geographic space, provides tools for spatial analysis, and performs simulations to help expert users organize their work in many areas including transportation, agricultural development, and environmental information systems (Rigaux et al. 2002).

The use of GIS in analyzing socioeconomic attributes along the spatial gradient has increased tremendously (Bowers and Hirschfield 1999). Several social researchers have utilized the system in developing comprehensive research outcomes, integrating socioeconomic information into the space, and sustainable policy formulation along the spatial gradient (Bhatta and Lynch 2011; Bhatta 2010; Bhatta and Neupane 2010; Bhatta et al. 2009; Codjoe 2007; K.C. 2005; Brown 2003; Louis and Magpili 2002; Evans and Moran 2002; Troyer 2002; Farzaghi 2002; Schreier and Brown 2001; Forghani 2000; Joshi et al. 1999; Ashby et al. 1999). Collecting socioeconomic data in a spatial context and maintaining original location-specific information could reveal patterns in the data, which would otherwise not be reflected in traditional socioeconomic analyses (Brown 2003).

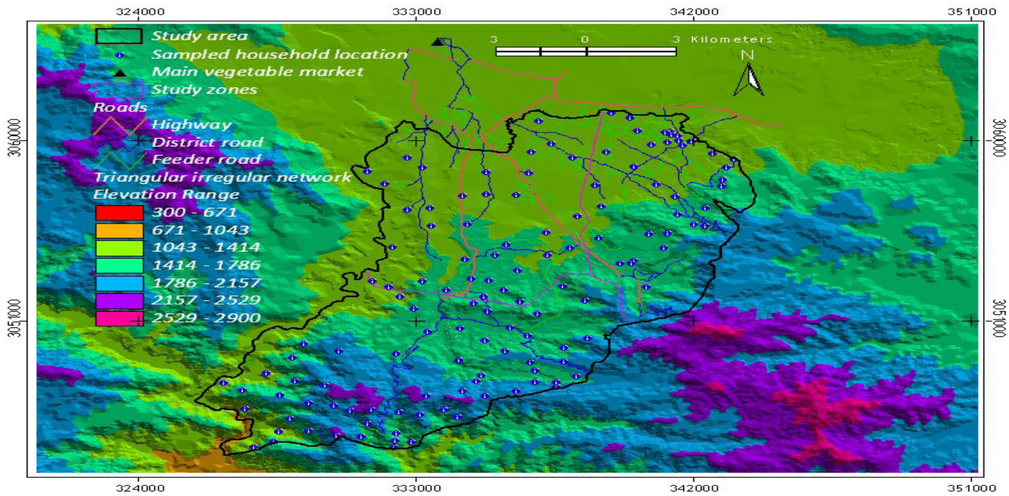
This study identifies farm-family resource distribution by integrating micro-survey data into a spatial environment. This is to see variations, if any, along the spatial gradient and their implications on farm families' livelihood development.

METHODOLOGY

The area covering Lalitpur and Bhaktapur districts in the mid-hill region of Nepal (Figure 1) was selected because of the following reasons:

1. This area has always been dominated by agricultural activity.
2. Vegetable production is commercialized and a large chunk of vegetables in the Kathmandu Valley has been supplied by farmers in this area.
3. Though not too far in terms of physical distance from the city, some villages within the districts are less developed (i.e., a complete rural setting) while other villages are prosperous with modest access to urban amenities.
4. Spatial variation is high. Different farming practices are also present in different locations.

Figure 1. Study area showing different farming zones and sampled household locations at different altitudinal ranges indicated by Digital Elevation Model (DEM)



Sampling Procedure

Prior to sampling, three broad farming practices were identified: (1) subsistence farming in rural areas, (2) commercial inorganic farming in the northwest peri-urban area, (3) and smallholder organic vegetable production in the northeast peri-urban areas of Lalitpur and Bhaktapur districts. Households were selected through spatial and simple random sampling. Spatial sampling was employed since information on the number of households in the study area was not available at the time of research.

Spatial sampling was employed to select 60 and 35 farming households from subsistence and commercial vegetable production areas, respectively. Meanwhile, 35 households from the smallholder organic vegetable production area were selected randomly. The 35 smallholder organic vegetable farming households were selected randomly because organic growers are settled within the smaller perimeter and spatial sampling with similar buffering distances would not capture the required sample size. Spatial sampling is based on the concept of spatial dependency, which relies on the principle of proximity of locations to one another. Locations that are close to one another are expected to have more similar values than those farther away (Tobler 1970). This method was selected because all households that were settled in the study area were surveyed.

Data Collection

Socioeconomic data were collected using a structured questionnaire administered through personal interview. The questionnaire was designed to capture socioeconomic information, farm-family resources, production methodologies, and farm inputs/outputs.

Different analog maps were purchased from the Nepal Department of Survey, which were used to prepare baseline GIS data for the study area. Such maps cover roads, rivers and streams, settlements, administrative boundaries, contour lines with 100 meter (m) spacing, and elevations. The Global Positioning System (GPS) was used to locate the households spatially.

Data Integration

The interdependencies between the farming populations and their spatial attributes can be determined by combining farming systems methodology, which is complemented by information extracted from geographical sources (K.C. 2005). Relevant socioeconomic data were combined with spatial data to find the geographical influence on farming systems development. The differentiation of spatial and socioeconomic attributes of the farm families give rise to different farming practices (Bhatta et al. 2009). This study analyzes the socioeconomic characteristics of farm families and integrates such information in a GIS environment to determine spatial relationships. Progressively, GIS technology is being employed by different users to create resource databases and to arrive at appropriate solutions or strategies for developing agricultural resources sustainably (Venkataratnam 2001).

The strength of GIS lies in its ability to integrate different types of data into a common spatial platform. This information should present both opportunities and constraints for the decision maker (Ghafari et al. 2000). The ability of GIS to integrate maps and databases, with geography as the common feature, has been extremely effective in the context of agricultural development and resource management. The integration of data allows the asking of complex spatial questions that could not be answered otherwise (Buckley 1997; Brown 2003). To link socioeconomic data with GIS, geographic locations of the sampled households were taken during the field survey using GPS. After linking the GPS receiver to a computer, the recorded data were exported into the Arc View GIS software. GIS software can deal with "many-to-one" relationships as well as the more common "one-to-one" relationships (Walsh et al. 2004). A common key field using household number was made for the point attribute table in GIS and the survey databank. Once a linking field (i.e., primary key) had been set up with the household number, data were integrated and a relational database was obtained. The flow diagram of data integration is depicted in Figure 3. Once data were integrated, they were subjected to spatial autocorrelation followed by interpolation of the autocorrelated socioeconomic variables.

Spatial Autocorrelation (SAC)

In many spatial data applications, the events at a location are highly influenced by the events at neighboring locations. The natural inclination of a variable to exhibit similar values as a function of distance between the spatial locations at which it is being measured is known as spatial dependency (Gangodagamage et al. 2008). There are two popular indices for measuring spatial autocorrelation in a point distribution: Geary's Ratio and Moran's I. Both measure spatial dependency for interval or ratio data (Lee and Wong 2001). Geary's C and Moran's I concern three possibilities of spatial patterns in their calculation, i.e., clustered, random, and dispersed (Table 1).

For measuring SAC, both Geary's Ratio and Moran's I combine the two measures for attribute similarity and location proximity into a single index of

$$\sum_{i=1}^{n}\sum_{j=1}^{n} c_{ij}w_{ij}$$

It is used as the basis of formulating both indices. In both cases, SAC is proportional to the weighted similarity of attributes of points, which could be expressed as (Lee and Wong 2001):

$$SAC = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} c_{ij}w_{ij}}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \qquad (1)$$

Table 1. Numeric scales for Geary's Index and Moran's Index

Spatial Patterns	Geary's C	Moran's I
Clustered: adjacent points show similar characteristics	0 < C < 1	I > E(I)
Random: points do not show particular patterns of similarity	C ≈ 1	I ≈ E(I)
Dispersed: adjacent points show different characteristics	1 < C < 2	I < E(I)

Source: Lee and Wong, 2001
Note: E(I) = (-1)/(n - 1), with n denoting the number of points in the distribution

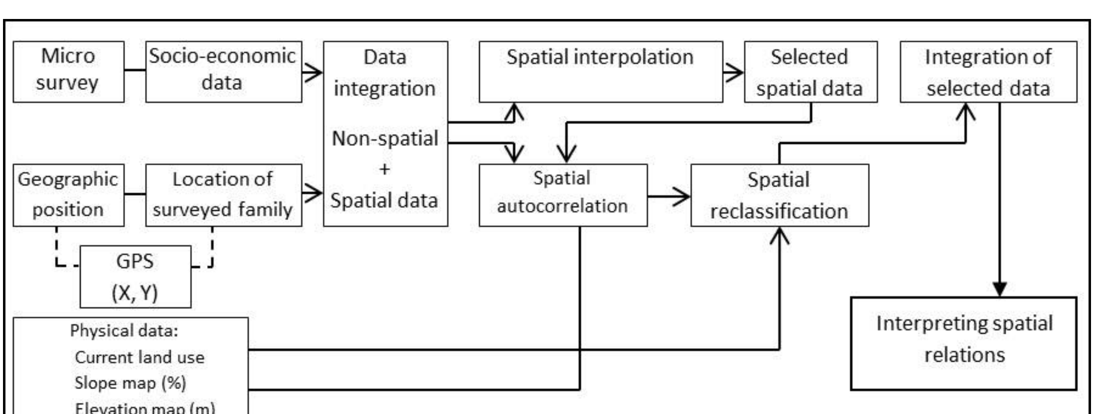
where: c_{ij} is similarity of point *i*'s and point *j*'s attributes; w_{ij} is proximity of point *i*'s and point *j*'s locations with w_{ij}= 0 for all points; x_i is the value of the attribute of interest for point *i*; and *n* is the number of points in the point distribution.

Figure 2 depicts the simplified flow diagram of all the steps of data integration into a GIS environment. Only a selected set of socioeconomic data was integrated into GIS and those variables showing SAC were interpolated. Physical aspects such as land use, slope map, and elevation were not analyzed spatially in this paper. Nevertheless, they appear in the discussion.

Spatial Interpolation

Spatial interpolation, which is a type of spatial prediction (O'Sullivan and Unwin 2003), estimates the variables at unobserved locations in geo-space based on the values at observed locations (Zhang and Goodchild 2002). The principle that underlies all spatial interpolation is the Tobler Law—points that are close together in space tend to have similar value attributes. Basic methods include inverse distance weighting (IDW), spline, kriging, and trend interpolation (Naoum and Tsanis 2004). This study employed IDW, which is one of the oldest and simplest approaches and perhaps the most readily available method (Longley et al. 2004). IDW is based on the weights, which are inversely proportional to the square of the distance from the center of the zone of interest (Kemp 2008). Hence, points closer to the location of estimation are weighted greater than those farther away. Output grid surfaces were created in which the value of each 25 m

Figure 2. Integration of socio-economic and biophysical data in GIS environment and process of spatial zoning



Source: Modified from Bhatta et al. (2009)

cell was calculated considering the values of 12 neighboring sample points and their distances to the point of estimation. A linear trend in the sample data was assumed for the model.

Figure 3 simplifies the IDW method. The point of interest is assumed as +, and the points where measurements were taken as x_i, where i runs from 1 to n, if there are n data points. Z_x represents the unknown value with known measurements as i, each of these points gets a weight d_i, which are evaluated based on the distance from x_i to x. Then the weighted average computed at x is:

$$Z_x = \frac{\sum_i w_i x_i}{\sum_i w_i} \tag{2}$$

There are various ways of defining the weights. However, the option most often employed is to compute them as the inverse of squares of distances.

$$W_i = \frac{1}{d^2} \tag{3}$$

This means that the weight given to a point drops by a factor of four when the distance to the point doubles.

Data Analysis

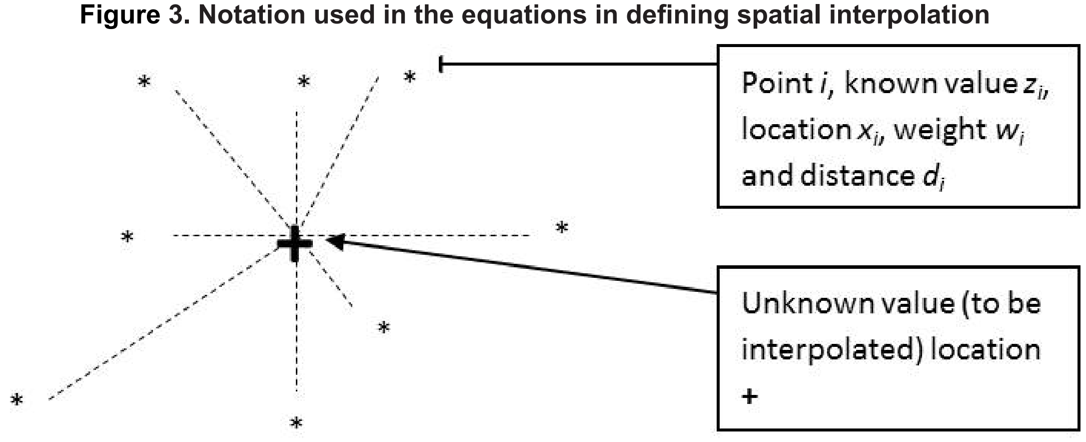
Descriptive analysis such as means and confidence interval of means were employed. The Kruskall-Wallis and Mann-Whitney tests were used for data sets that violated the assumption of normality while ANOVA was used for normally distributed data. The confidence interval was fixed at 95 percent. The descriptive analysis along with parametric and non-parametric tests for groups was done using SPSS 16.0. Graphical presentation was made using SigmaPlot 10.0 and Arc View 3.3 was employed for spatial explicit analysis.

RESULTS AND DISCUSSION

Farm Family Resource Distribution

This section covers farm-family resource distribution along the spatial gradient. It also analyzes socioeconomic attributes descriptively. Farm-family resources include human, land, and livestock resource and farm production along with farm-family income.

Figure 3. Notation used in the equations in defining spatial interpolation



Source: Longley et al. 2004

Family size and dependency ratio

The results show that the average family size was 7.04 in subsistence farming, 5.58 in commercial inorganic farming, and 5.86 in organic vegetable farming (Figure 4). At the national level, the average family size was 5.4 (Central Bureau of Statistics [CBS] 2007). Meanwhile, it was 5.36 in rural areas (CBS 2005), 5.47 in Bhaktapur district, and 4.9 in Lalitpur district. The results from the Mann-Whitney test show that family size of subsistence farmers was significantly higher than the others while commercial inorganic and organic vegetable farmers were on par. Family size is higher in rural areas because of a lower level of education, lack of awareness about family planning (CBS 2005), and the need for more family members for farm labor (Bhatta and Doppler 2010; 2011).

The dependency ratio is a measure of the portion of a population that is composed of dependents that are too young or too old to work. An elevated dependency ratio is of concern since dependents do not contribute economically but share the economic resources of the household (Blair 2007). Under the circumstances of extreme limitations of such resources, an elevated dependency ratio would obviously exacerbate poverty. At the national level, the dependency percentage was 77.23. In rural areas, it went as high as 94.9 percent (CBS 2007). The dependency ratios, albeit higher in the subsistence farming group, were not significantly different (Figure 4). A higher dependency ratio in subsistence farming is normally due to the desire of a married couple to have more children. This is due partly to lack of education and the need for more family laborers (Bhatta 2010; CBS 2005). Farm families in the rural hills have poor livelihoods because of higher dependency ratio and lack of off-farm employment opportunities.

Educational status

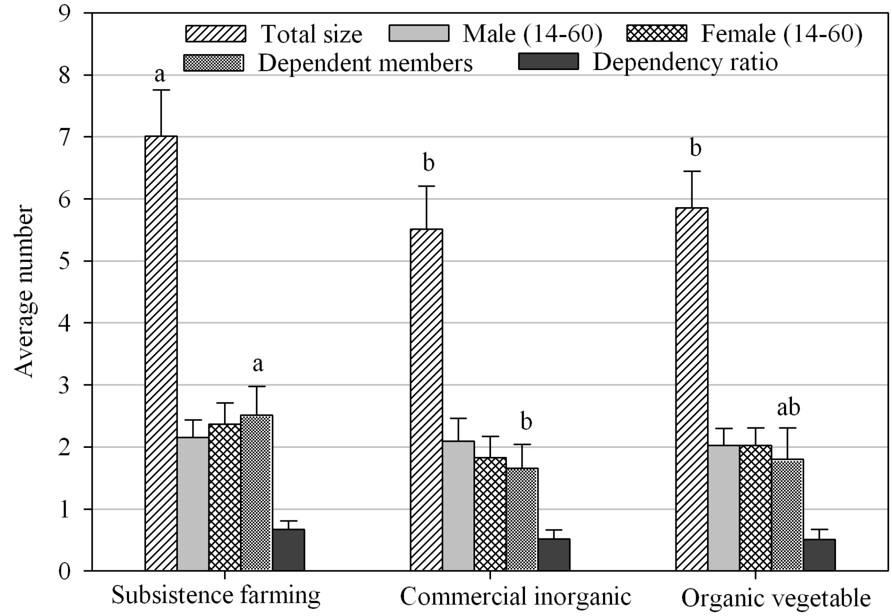
The empirical results show that the educational status of the farmers in the study area was better in the organic vegetable production zone compared to the others (Figure 5). More family members were illiterate and pursuing primary level of education in the subsistence farming group compared to the others. In all groups, there were fewer individuals with college-level education compared to those without. Family members with college-level education differed significantly across groups. The low level of education in the subsistence farming group is due to low access to educational institutions nearby; inability to afford to higher education, which is generally available in the city centers far from their residence; and the requirements of more labor force in household and farm activities (Bhatta 2010). While the two other areas are near the capital, where most of the academic institutions are and where farmers could afford education, rural areas do not have adequate academic institutions and most of the farmers could not afford the quality of education available in the city centers.

Family labor force

Analysis of the family labor force provides insight on how family labor force is allocated to different activities. The internal allocation is among the farm, family affairs, and household activities while external allocation is for off-farm activities.

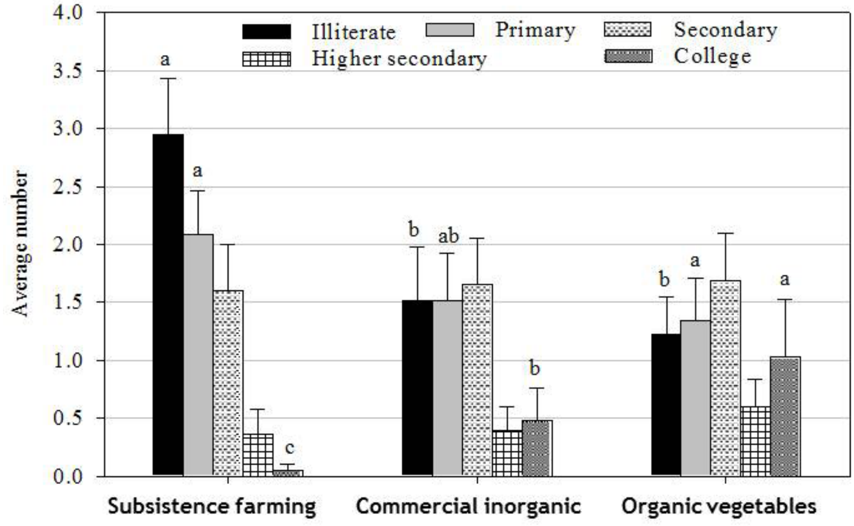
The mean family labor for household work was significantly higher in the organic vegetable production group compared to commercial inorganic farming. In contrast, the mean family labor for farm work was significantly higher in subsistence farming compared to commercial inorganic farming and was on a par with that of organic vegetable farming (Table

Figure 4. Distribution of family size across different farming areas



Note: Error bars represent standard error of the mean (SE). Similar bars with identical letters are not significantly different among groups at 0.05 level of probability according to the Mann-Whitney test.

Figure 5. Educational status of the family members, by study zone



Note: Error bars represent standard error of the mean (SE) and similar bars with identical letters are not significantly different among the groups at 0.05 level of probability according to the Mann-Whitney test.

2). More males and females were involved in off-farm activities in the organic vegetable production group, which is basically due to their higher levels of education, availability of off-farm opportunities nearby, and tendency of both males and females to be independent economically. Similarly, significantly more family members were engaged in their own enterprises in organic vegetable farming. As accessibility decreases, the tendency of family members to be involved in off-farm activities also decreases. Most of the family members in remote areas under subsistence farming constituted farm labor either in their own farm and/or in others' farms. Involvement of more members as farm laborers means less income as wage rate is lower. Hence, this would lead to poor living standards of the farm families in remote areas.

Land area availability

Quality and quantity of land availability determine the living standards of farm families. Moreover, the type of crops grown on it, productivity, and market value of the produce largely shape families' livelihoods. The results show that the average land holding was substantially larger in subsistence farming followed by organic vegetable farming (Figure 6a). Although land availability in rural areas was higher, the production potential of land was lower. Land in urban areas is very inelastic in supply. It has huge value with rapid transformation from agriculture to non-agricultural activities. The reason for this rapid transformation is the centric nature of economic development along with a growing sense of insecurity in rural areas (Bhatta 2010).

Relatively plain land availability is significantly higher in organic vegetable production area compared to others while sloped (bari) land, forest, and grazing land are significantly higher in the subsistence farming zone. The average land holding per family in subsistence farming is almost equal to the national average, which is 0.8 hectare (ha) (CBS 2006). Meanwhile, in the other two zones, families have land sizes almost equal to that of the Kathmandu Valley, which is 0.26 ha (CBS 2005). Significantly higher area planted to maize is found in the subsistence farming zone. This is obvious because most of the land is sloping and maize is the most important food as well as

Table 2. Family labor used in farm, household, and off farm activities by farming zone

Labor capacity	Subsistence Farming (n=60)	Commercial Inorganic Farming (n=35)	Organic Vegetable-based (n=35)
Mean family labor in household work	2.97^{ab} (±0.30)	2.49^{b} (±0.36)	3.37^{a} (±0.51)
Mean family labor in farm work	3.70^{a} (±0.33)	3.00^{b} (±0.44)	3.50^{ab} (±0.46)
Mean number of males in off farm work	0.97 (±0.22)	0.83 (±0.28)	1.20 (±0.31)
Mean number of females in off farm work	0.19^{b} (±0.19)	0.54^{b} (±0.26)	0.77^{a} (±0.25)
Total off farm work	1.43 (±0.34)	1.37 (±0.43)	1.97 (±0.48)
Own enterprise	0.18^{b} (±0.14)	0.23^{b} (±0.19)	0.54^{a} (±0.29)
Salaried work	0.78^{b} (±0.23)	0.89^{b} (±0.29)	1.29^{a} (±0.35)
Laborers	0.47 (±0.24)	0.26 (±0.21)	0.17 (±0.58)

Note: Figures in parentheses are 95% confidence interval of the mean; Letters in superscript show the significant difference among groups at 0.05 level of probability according to the Mann-Whitney test and values with identical letters are not significant.

feed crop in the mid-hill slope lands of Nepal (Rajbhandari and Bhatta 2008). Similar to this is the area covered by mustard and legumes. Significantly higher area planted to different kinds of vegetables is found in the organic production zone compared to subsistence farming. The former is at par with commercial inorganic farming (Figure 6b). Farmers near the market center (i.e., peri-urban plain lands) tend to grow vegetables commercially. However, farmers in the subsistence farming area produce vegetables in the kitchen garden mainly for home consumption. This is the reason why there is more area planted to vegetables in peri-urban hinterlands.

Areas cultivated for rice, wheat, maize, potato, buckwheat, mustard, and some minor food crops have been summed to determine the total food crop area, which was used for interpolation. Spatial difference in food crop area is prominent—households with poor access to urban amenities have larger holdings and are more reliant on subsistence production (Figure 7). Households with road access have smaller landholdings and are more reliant on off-farm employment to meet their families' needs. Brown (2003) noted similar spatial tendency of landholdings in the mid-hills of Nepal.

Tropical livestock unit (TLU)

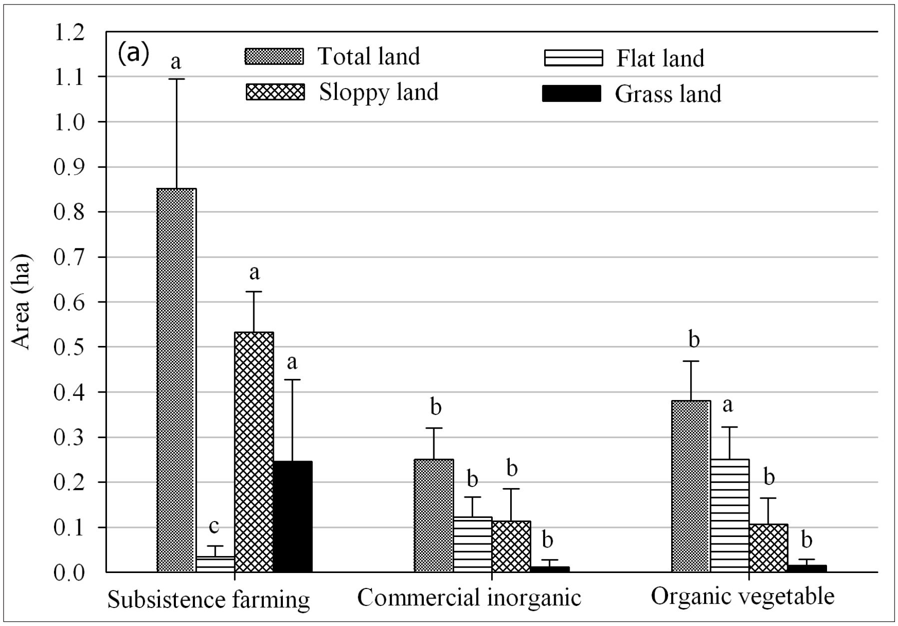
Livestock unit, which is measured as the number of animals per farm, has an inherent weakness in that it ignores species and age groups (Katwijukye 2005). Therefore, the available animal units in the study area were expressed in a standardized term called TLU. This parameter is adopted because it allows pooling together animals of different age groups and species and gives a relative figure for computation (Kaburanyaga 2007). In general, TLU is significantly higher in the subsistence farming group (6.30) followed by commercial inorganic farming (2.14) and organic vegetable farming (1.44). Higher TLU in the rural areas is basically due to a higher number of cows and buffaloes and their consequent higher contribution to TLU. Spatial distribution of TLU shows clear variation in the space. A cluster of higher TLU is found in rural areas and it decreases from remote to urban areas (Figure 8). In urban areas, buffaloes are generally not reared. Some farmers have a few units of poultry primarily for home consumption. The reverse is true in remote areas where many farmers rear cows, buffaloes, and goats for selling at the market as well as for home consumption. Integration of livestock with agriculture and forest is one of the fundamental aspects that sustain the rural farming system.

Farm-family income and analysis of infrastructure

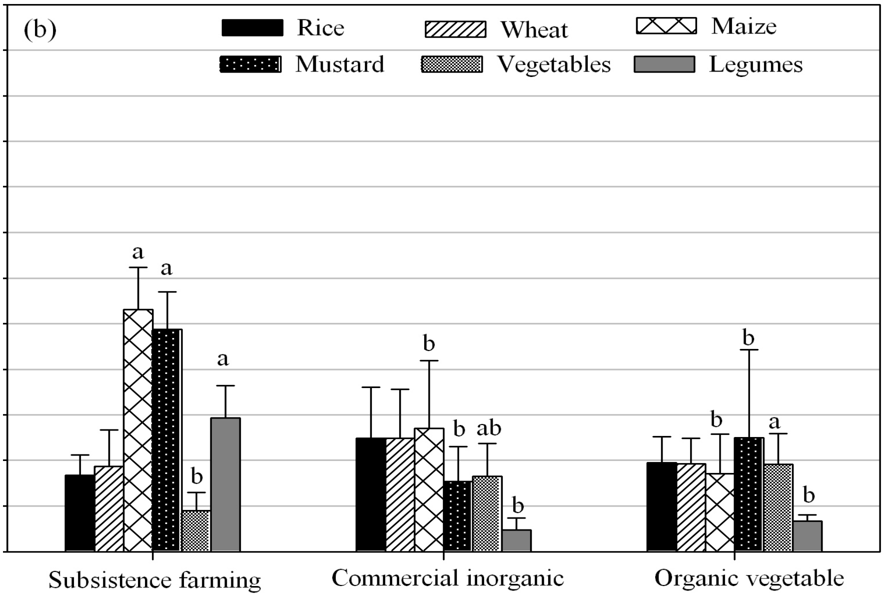
Farm-family income was calculated by considering revenues and expenses of all farm activities, off-farm income, and income from other sources. Spatial clusters of farm-family incomes were found in the study area. Farm income was relatively low in the high altitudinal gradient and it became higher in the flat lands near urban centers (Figure 9). The trend on family income was similar to farm income but with apparent pattern in the space. It was lower in remote areas and increased as the area neared urban centers. There was lower farm income as well as a lack of off-farm employment opportunities in rural areas. These, along with market-oriented production, lower cost of transportation, and better off-farm employment eventually led to high family income. Higher farm and family incomes were found in the road transects mainly around the highway and the main roads. This mirrors the strong infrastructural link for better livelihoods.

Figure 9 also shows the major roads

Figure 6. Average land area in different farming zones; (a) area of different types of land, (b) area planted to different crops



Note: Error bars represent standard error of the mean (SE) and similar bars with identical letters are not significantly different among the groups at 0.05 level of probability according to the Mann-Whitney test.



Note: Error bars represent standard error of the mean (SE) and similar bars with identical letters are not significantly different among the groups at 0.05 level of probability according to the Mann-Whitney test.

Figure 7. Spatial distribution of food crops' area (interpolation of the point-based data, 20 ropani = 1 hectare)

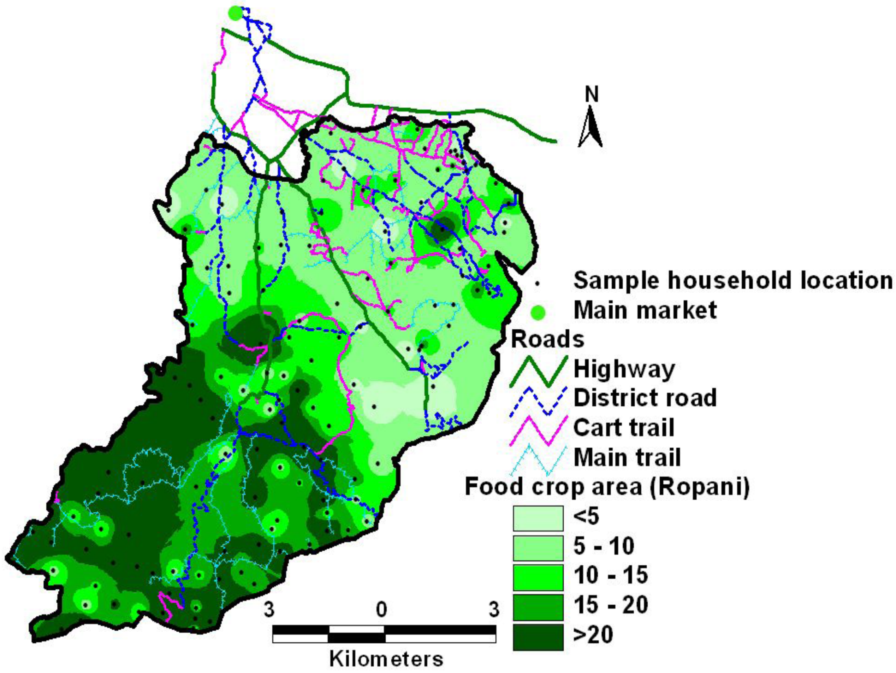


Figure 8. Spatial distribution of the livestock units in terms of TLU (IDW interpolation of point-based data)

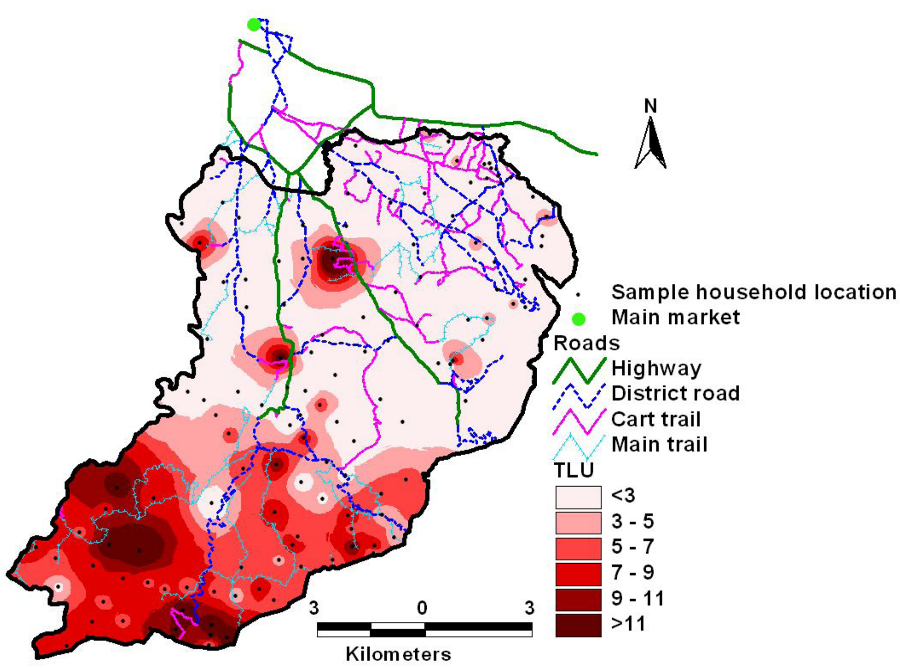
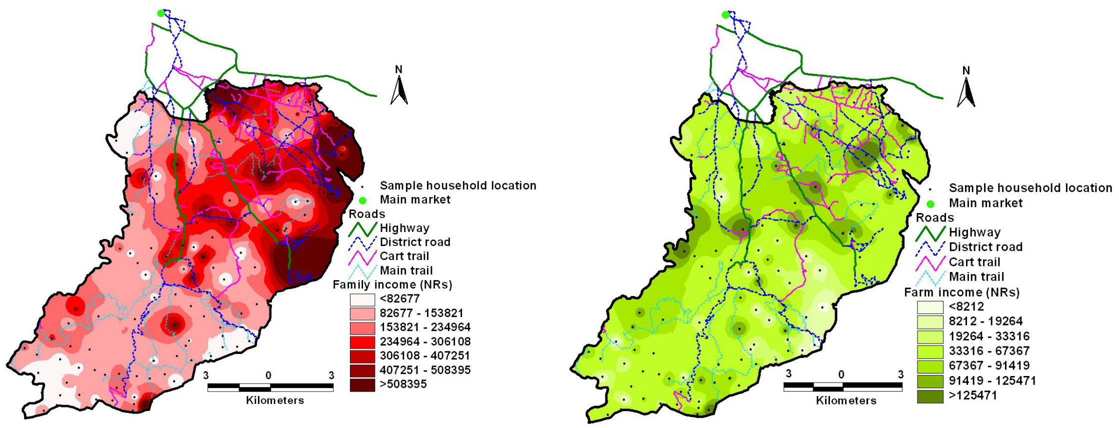


Figure 9. Spatial distribution of income (in Nepalese rupee [NPR]) in the study area; (left) family income (USD 1 ≈ NPR 73); (right) farm income



available in the study area and central market for the farmers. Highways transect only a portion of the study area. Most of the urban infrastructure such as satellite markets, urban markets, electricity, academic institutions, and industries, to name a few, were available or present around highways and district roads. District roads were also limited to a few rural villages, and most of the rural areas lack year-round road facilities. These, along with the lack of other infrastructure, have led to poor farm production, less farm income per se, and lower family income. The central market, which is the main hub for efficient input-output relations for the farmers of study area, could be accessed easily from the peri-urban parts because of the good road network available. This accessibility reduces cost distance for the farmers. The cost distance to access input-output markets for the farmers in rural hills would be appreciably higher (Bhatta 2010), which is why there is poor market relations among farmers and lower income of farm families in rural areas.

Spatial Dependency

The result of spatial dependency shows that there is strong spatial correlation of selected socioeconomic attributes and farm-family resources (Table 3).

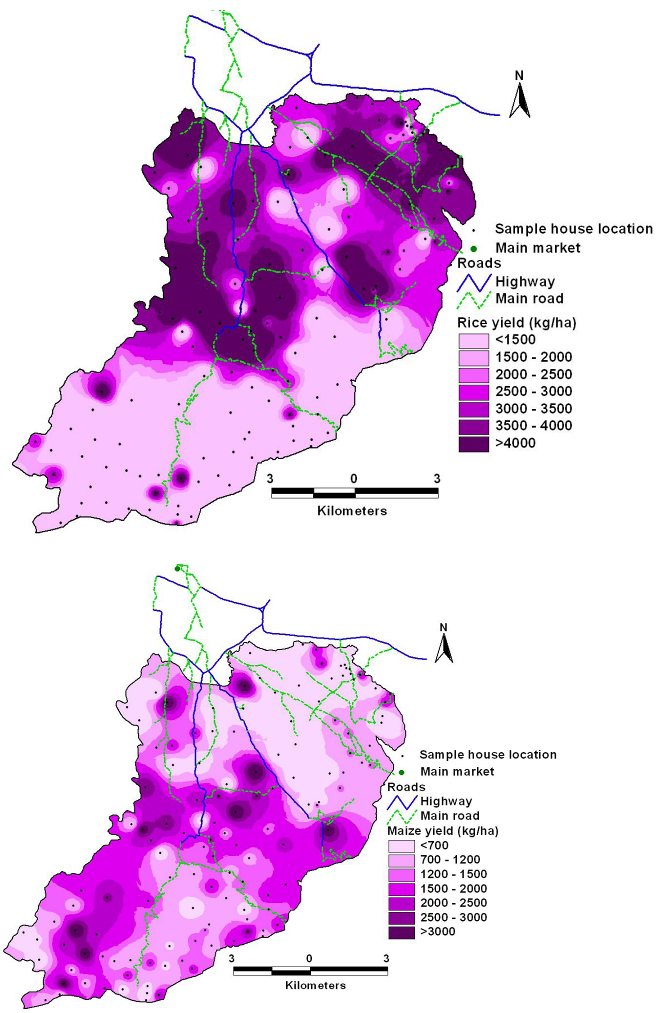
Paddy area and yield, for example, were higher in the less sloped land near input-output market. Meanwhile, paddy production declined with increasing slope and altitude (Figure 10a). Conversely, yield of maize was higher in the sloping land compared to the plain area (Figure 10b). The same applies to livestock revenue. Variations in altitude along the gradient are shown in Figure 1.

Income parameters such as farm, off-farm, and family incomes are lower in remote areas and higher in accessible areas. Other variables that show spatial dependency are food crop area, TLU, vegetable, and livestock revenues. A very strong SAC is found with TLU, maize area, and paddy yield as they have lower Geary's C value. This shows that most of the socioeconomic

Table 3. Results of spatial autocorrelation test of some important socioeconomic variables

Variable	Moran's I	Z score	Geary's C	Z score
Paddy yield (kg/ha)	0.200464	12.72070	0.797864	-8.03372
Rice area (ha)	0.078837	5.29011	0.919736	-3.19003
Maize yield (kg/ha)	0.126023	8.17284	0.850695	-5.93401
Maize area (ha)	0.198074	12.57470	0.770373	-9.12633
Food crop area (ha)	0.097952	6.45789	0.903444	-3.83754
Tropical livestock unit	0.207522	13.15090	0.769939	-9.19376
Livestock revenue (NPR)	0.025794	2.04949	0.986995	-0.51689
Vegetable revenue (NPR)	0.112219	7.32949	0.876086	-4.92488
Off-farm income (NPR)	0.042458	3.06756	0.850536	-5.94034
Family income (NPR)	0.039848	2.90800	0.85957	-5.58129

Figure 10. Spatial distribution of rice (top) and maize (bottom) yields (kg/ha)



parameters are being shaped by the spatial position of the farm households. Therefore, any intervention to uplift the standard of living through agricultural development should take the spatial variation into account and the influence it exerts on farm-family resources availability and use.

CONCLUSION

Spatial variations in terms of farm-family resource distribution were seen clearly along the gradient. In rural areas, for instance, farm-family income was lower while it increased toward the less sloped peri-urban areas. With increasing slopes, there was a gradual decrease in flat lands, area planted to vegetables, and paddy yield. Meanwhile, there was gradual increment in family size, area of slope lands, area used for food crops, TLU, and maize yield. Rural farmers had poor living standards, owing to a higher altitudinal location of their farms along with the lack of highly needed infrastructure such as roads, off-farm employment opportunities, and efficient market relations. The low-lying valley hinterlands had good access to road and other infrastructure including off-farm employment opportunities, which have led to a higher living standard of farm families. Differential resource availability along the spatial gradient was present. Hence, different farming practices were being followed by the farmers to suit their farming activities to resource availability.

Spatial explicit analysis of the socioeconomic data and farming practices has implications on policy and project development, particularly road and agricultural development projects. Therefore, any project aimed at developing farm families' livelihoods should nurture spatial variation and consider spatial integrity of socioeconomic aspects rather than household characteristics only.

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