

Population Dynamics and Land-Use Changes: A Case Study of Jhikhu *Khola* Watershed, Nepal

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Objective

- To assess and study the interrelationships between population, natural resources and land-use changes in mountain watersheds for developing a better understanding of these relationships and formulating better policies and intervention mechanisms

How to assess the population dynamics in Jhikhu *Khola* watershed?

Population information for each village development committee (VDC) is available over time, but in most cases the VDC boundaries cross the Jhikhu *Khola* watershed (JKW) boundary. Only two are totally within the JKW; the remaining VDC boundaries extend outside the watershed. Selective aerial photographs on a scale of 1:20,000 were enlarged to 1:5,000 and used for counting all houses. The number of houses was multiplied by the average family size determined for each VDC through surveys and interviews. This methodology seems appropriate and reliable for the study of population dynamics. The 1947 numbers were obtained from

1:50,000 scale topographical maps and the average family size was obtained from historic census data. To check for manual errors, 10 per cent of the households were selected from the total of each VDC. The family size of these households was compared to the estimated average.

How is land use in JKW estimated?

Land use was determined from aerial photographs (1:20,000 to 1:25,000 scale) and field surveys for 1972, 1990 and 1996. General land-use categories such as irrigated land, rainfed terraces, forest, grassland, shrubland and others were delineated on each photograph. Additional details were collected during field work.

Geographical information systems (GIS)

All land-use information was digitised into a GIS using Terrasoft in order to create a detailed land-use inventory for the watershed. Total areas and units in the various land-use categories were determined from the digital database, and land-use changes over different time periods were examined by GIS.

Table 1: Population Distribution of Jhikhu *Khola* Watershed

VDC	1947			1990			1996		
	Household #	Family size	Population	Household #	Family size	Population	Household #	Family size	Population
Anaikot	124	4.7	583	445	5.6	2492	619	5.6	3466
Baluwa	148	5.8	858	568	6.7	3806	1066	6.7	7142
Banepa	6	5.8	35	18	5.6	101	18	5.6	101
Devitar	99	5.8	574	343	6.3	2161	406	6.3	2558
Dhulikhel	128	7.8	998	304	6.0	1824	557	6.0	3342
Hokse	70	5.8	406	338	5.2	1758	468	5.2	2434
Kabhre	75	5.3	398	462	5.4	2495	538	5.4	2905
Kharelthok	102	5.8	592	353	4.9	1730	375	4.9	1838
Maithinkot	51	5.8	296	220	5.4	1188	266	5.4	1436
Panchkhal	250	5.8	1450	1117	6.5	7261	1638	6.5	10647
Patlekhet	246	5.8	1427	477	6.2	2957	807	6.2	5003
Phoolbari	52	5.3	276	179	5.6	1002	214	5.6	1198
Rabi Opi	104	5.8	603	422	7.1	2996	685	7.1	4864
Sathighar	82	5.8	476	228	5.2	1186	345	5.2	1794
Total	1537	5.8	8971	5474	5.8	32956	8002	5.8	48728

The population status of the watershed in 1947, 1990 and 1996 is provided in Table 1. The data show that the overall population has increased from 8,971 in 1947, through 32,956 in 1990, to 48,728 in 1996.

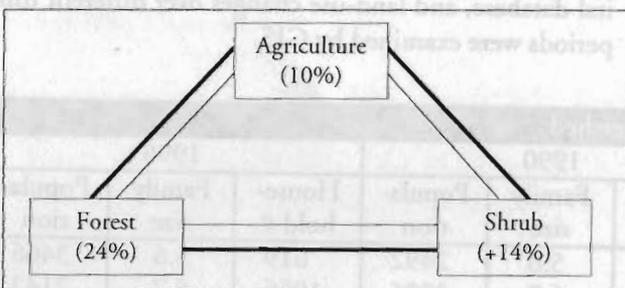
Population growth from 1947 to 1990 averaged 3.0 per cent. From 1990 to 1996 the number of houses has increased by 5.7 per cent.

Land-Use dynamics in the JKW between 1947, 1972, 1981, 1990 and 1996

From 1980 to 1994, the average cropping intensity in the watershed increased from 1.3 to 2.3. To understand and quantify the trends of land-use dynamics, historic land use (1947, 1972, 1981, 1990) and recent land use (1996) have been compared. Quantification and analysis of land-use changes between these various periods were carried out by applying GIS technology.

Broad land-use changes between 1947 and 1981

In 1947, general land use was mapped delineating forest, shrubland and agriculture. The spatial distribution of land use for 1947 and 1981 is presented in Map 1. This assessment shows an overall gain of 10 per cent in agriculture and 14 per cent in shrubland. It indicates substantial forest deterioration over this period. A significant net conversion of forest into agricultural land of about 1,164 ha and forest deterioration into shrubland of some 1,551 ha is absent.



Map 1: Land use in 1947 and 1981

The land-use changes over the period of 18 years were examined using GIS. There were substantial increases in forest of 10 per cent, and *bari* (dry land cultivation) of 5 per cent while *khet* (irrigated fields) increased by only 1 per cent, shrubland decreased by 9 per cent and grassland by 5 per cent (Table 2).

GIS results show that forest has increased over this 18-year period: 738 ha from shrubland and 317 ha from grassland. *Bari* has also increased: 250 ha from shrubland and 224 ha from grassland.

There has also been a change in forest species' distribution. The increase in forest cover due to pine plantations is 63 per cent. Sixty-five per cent of all pine plantations are on slopes of less than 35 per cent with the largest area in the 20-35 per cent slope range. Eighty-four per cent of the plantations are below 1,200m. During the 1972-1990 period, significant agricultural changes occurred in two directions: expansion on to marginal land and crop intensification. *Bari* increased by 5 per cent from 1972 to 1990. Sixty-six per cent of all sites converted into *bari* occurred on slopes greater than 20 per cent. The highest land conversion occurred in the 36-49 per cent slope class. This clearly suggests that a critical limit was being reached in dry land cultivation during the period from 1972 to 1990. Lowland irrigated agriculture intensified over this period with the introduction of high-yielding crop varieties and application of mineral fertilizer.

Land use 1990 - 1996

The six major land-use categories were compared by superimposing the land use of 1990 and 1996 using GIS. The GIS analysis shows that between 1990 and 1996 there has been an expansion of grassland and *khet* by 1 per cent balancing a similar loss of shrubland and *bari* (Table 3). There were significant increases in forest cover from 1972 to 1990 but almost no changes from

Table 2: Land Use in 1972 and 1990

Landuse Types	1972		1990		% Change
	Area (ha)	Area (%)	Area (ha)	Area (%)	
<i>Khet</i>	1653	15	1719	16	+1
<i>Bari</i>	3844	34	4354	39	+5
Forest	2181	20	3359	30	+10
Grassland	1184	11	466	4	-7
Shrub	1857	16	937	8	-8
Others	422	4	306	3	-1
	11141	100.0	11141	100.0	0.0

Source: Land-use maps of ISS, Topographical Survey Branch, Department of Survey Scale 1:20,000

Table 3: Land use 1990 and 1996

Landuse Types	1972		1990		% Change
	Area (ha)	Area (%)	Area (ha)	Area (%)	
<i>Khet</i>	1719	16	1838	17	+1
<i>Bari</i>	4354	39	4264	38	-1
Forest	3395	30	3319	30	+<10
Grassland	446	4	613	5	+1
Shrub	937	8	781	7	-1
Others	306	3	326	3	+<2
	11141	100.0	11141	100.0	0.0

Source: Land-use map of PARDYP/ICIMOD. Scale 1:20,000.

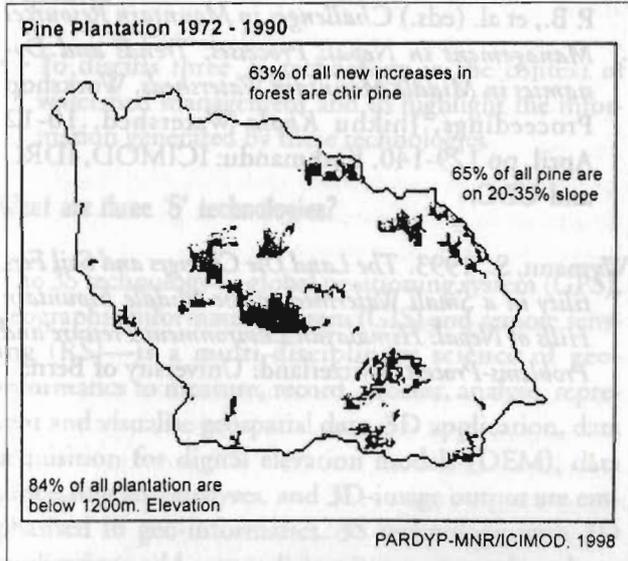


Figure 1: Land use dynamics 1972 to 1990 (1:20,000)

1990 to 1996. The expansion of *khet* was mainly from *bari* during this period, with about 119 ha of land converted from *bari* to *khet*.

Population and land-use dynamics in JKW

There is a close relationship between population growth and land-use dynamics in the JKW. During the last fifty years the population has increased significantly influencing land use and cropping systems. Population growth has resulted in a dramatic decrease of per capita agricultural land from 0.62 ha/capita in 1947 to 0.18 ha/capita in 1990 and 0.11 ha/capita in 1996. To meet the increasing demand for food, agriculture has intensified and expanded on to marginal upland slopes. The pressure on forest resources also appears to be increasing as illustrated by recent losses of sal (*Shorea robusta*) forest.

Summary and conclusions

Aerial photography and GIS are useful tools for documenting and quantifying trends and processes of population and land-use dynamics. This methodology can be used in any watershed study of mountain regions

and can provide information that is generally not available from government sources.

Population growth increases the demand for food and places an additional pressure on limited resources; this has quickly affected land-use practices in the Jhikhu *Khola* watershed. From 1990 to 1996 farmers practised more commercial farming systems, and *khet* expanded by one per cent. Between the 1970s and 1990s the cropping patterns were mainly dominated by rice, wheat and some potatoes on the *khet*, and maize, mustard, wheat or millet on the *bari*. From 1990 to 1996 the cropping system has changed to include more diversified crops dominated mainly by rice, potato, tomato, wheat and early maize on *khet* and maize, wheat, mustard, tomato, potato and some millet on *bari*. More and more farmers are practising commercial cultivation of potatoes, tomatoes, radishes, onions, and garlic. The change from largely subsistence to more commercial farming systems in the JKW over the last six years is due to the development of market centres and the extension of motorable secondary roads; during the last six years more than six secondary roads have been constructed. Milk-chilling centres, telephone facilities, rice mills, a college, etc. were also established.

The three sets of assessments record deforestation from 1950 to 1970, significant plantation from 1972 to 1990, and almost no change from 1990 to 1996. GIS analysis shows that about 47 per cent of all increases in forest are pine below 1200 m elevation, and 65 per cent of all pine plantations are on slopes of less than 35 per cent.

At the same time, annual crop rotation intensified from an average 1.3 in 1980 to 2.3-2.7 in 1994, and this was accompanied by expansion of agriculture into marginal environments. Agricultural intensification may indirectly be helping to protect the forest: limited time is available for fuelwood, fodder and litter collection. Farmers are applying more and more chemical fertilizer and pesticides. Maintenance of soil fertility (organic matter, nutrients, and soil pH) may become a serious issue in the future.

References and further reading (not necessarily cited in the text)

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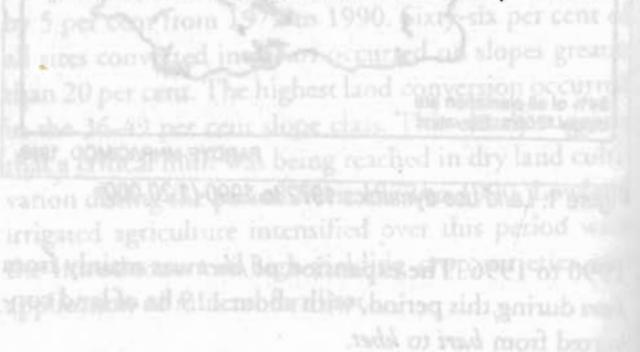
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