Socioeconomic and Environmental Change in Pokhara Valley, Nepal: a Study using Satellite Remote Sensing and Other Information

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Abstract: Pokhara valley is a popular tourist resort in Nepal and one of the most beautiful towns in the Himalayan region famous for majestic view of Himalayas and its beautiful lakes. It is also well known for rich cultural heritage. In recent years, Pokhara has been famous as a gateway to the Annapurna region, which has been described as one of the most fascinating trekking routes in the world.

While there has been marked increase in the flow of tourists, Pokhara has also witnessed a rapid urbanization in the last several decades, with the population increasing around 50 times in the past fifty years. The growth of tourism together with the increasing population and the associated activities have come with many consequences influencing its environment and also the socio-economic conditions and life style and culture of the people.

This paper presents a study aimed at demonstrating the changes that have taken place in the area over the past five decades, with the use of aerial photos, high and medium resolution satellite imagery and other available data of the past period. An analysis has been made on the change in land use and environmental conditions of the area, and this has been related with the increase in population and the economic activities in the region. The results have been presented in a simple way so as to make it understandable to the general public, aimed at generating awareness on the changing environmental condition of the city.
Keywords: Pokhara, remote sensing, urbanization, environment

1. Introduction

The valley of Pokhara is famous in Nepal and all over the world for its beautiful lakes and majestic view of Himalayas. It is one of the most popular tourist destinations in Nepal. Figure 1 shows the Landsat TM Image of Pokhara with three distinct lakes, Phewa in the west and Begnas and Rupa in the east, and the city area in between. Over the last several decades, Pokhara has witnessed a very rapid increase in population and the resulting urbanization, which obviously results in various environmental consequences. Besides the problem for management of the city, in the last few decades, there has been concern on the conservation of lakes, since it has been said that the lakes have been diminishing in size due to sedimentation and siltation. However, this is not a sudden process occurring overnight and thus in order to assess objectively whether the size of the lakes is reducing, and to find out the extent of any such changes, we need some scientific basis. Remote sensing provides excellent way to monitor such changes. An attempt is made here to demonstrate such changes through the use of remote sensing, with a combination of aerial photography and satellite remote sensing.

Pokhara is the second most important city in Nepal besides Kathmandu. The urbanization in Kathmandu has already been in so extensive and unsystematic that it is now very difficult to manage the city properly. Even though Pokhara has not reached that stage yet due to still relatively less population than Kathmandu, it is important to draw lessons from the Kathmandu experience in proper planning and management of Pokhara before it is too late. Various studies suggest the urbanization taking place in Pokhara (Adhikari, 2002; Basnet, 1992, etc) Thus it is also one of the aims of the study to demonstrate different future scenarios considering the business-as-usual policy, as well as other policy measures so that it will be possible to create awareness among the decision makers, development workers and general people on the need to take appropriate actions.


Fig. 1: Landsat TM image of Pokhara acquired in 1991, showing three lakes and the town.

2. Objectives

The following are the objectives of this study:

1. To study the changes in land use and environment of Pokhara in past fifty years.
2. To relate the change in environment with the changing socioeconomic and cultural perspective.
3. To make future scenarios under different policy interventions and make appropriate recommendations

3. Data used

The following data have been used in this study:
Aerial photos from 1954 (obtained from Forest Statistics and Survey Division), 1972, 1978, and 1998 (obtained from Department of Survey)
Medium resolution satellite data: Landsat TM from 1991 and 1999
High resolution satellite data: Quickbird image from November 2004

Other data:
Digital topographic data, population data, personal photographs from old times, etc.

4. Methodology

The following methodology was used in this study.

i. Ortho rectification and Geometric Correction of Data
Since aerial photos and satellite data were used from different dates, they were ortho rectified and geometrically corrected as applicable. Since the aerial photographs are in the analogue form they were first scanned to convert into the digital form.

ii. Classification for land use/cover

Then the classification was made for different land use and cover from aerial photos and satellite imageries. For this, a combination of visual interpretation and digital classification is employed.

iii. Change analysis

A change analysis was made to study the change in land use and cover, such as in the change in water bodies, built up areas, etc. This was then related with other data such as digital elevation data, population etc, to related the environmental change with socioeconomic changes.

iv. Scenario generation

First of all, a simulation of future land use/cover, including for urban areas and for lake water is simulated assuming a business-as-usual scenario. Then similar simulations are generated under different types of policy interventions so as to demonstrate the effect of different policies on urban management and lake conservation.

5. Results and Discussion

Preliminary results have been completed and it has clearly shown the effect of rapid urbanization and population pressure on the environment of the Pokhara valley.

One major effect has been on the decrease in size of the lakes. Of the three big lakes (Phewa, Begnas and Rupa), the area of the biggest lake (Phewa) has reduced significantly over the past fifty years. The size of another lake Rupa (so called because of its beauty), has been reduced severely and is under threat of extinction. Figure 1 shows the Phewa lake and surrounding areas in aerial photograph of 1991. Figure 2 shows the Quickbird image of the same area acquired in November 2004. In both images, the waterbody of Phewa lake has been marked blue for clarity. Comparing the two figures, it can be clearly seen that the area of Lake has clearly diminished in fifty years time, with significant area in the north west of the lake (near to the feeder river) being deposited with sediments carried by the river. Also, on the eastern side of the lake, while there is almost no built up area at all in 1954 (it was a small village with few scattered houses with thatch roofs), the 2004 image clearly shows a modern built up area with many roads, concrete buildings all over the area. Table 1 shows the change in size of Phewa lake area over time.

Table 1: Changing size of Phewa Lake over last five decades

Date	Data source	Area of water body
1954	Aerial photograph	5.37 Km^2
1972	Aerial photograph	4.68 Km^2
1990	Landsat TM	4.47 Km^2
1999	Landsat TM	4.37 Km^2
2004	Quickbird image	4.24 Km^2

Thus the size of the Phewa lake is already reduced by more than 20% in the last fifty years. If the business as usual scenarios continue, the lake may disappear or may be reduced to a small pond in next 150 to 200 years, which is a serious problem for the identity and environment of Pokhara.

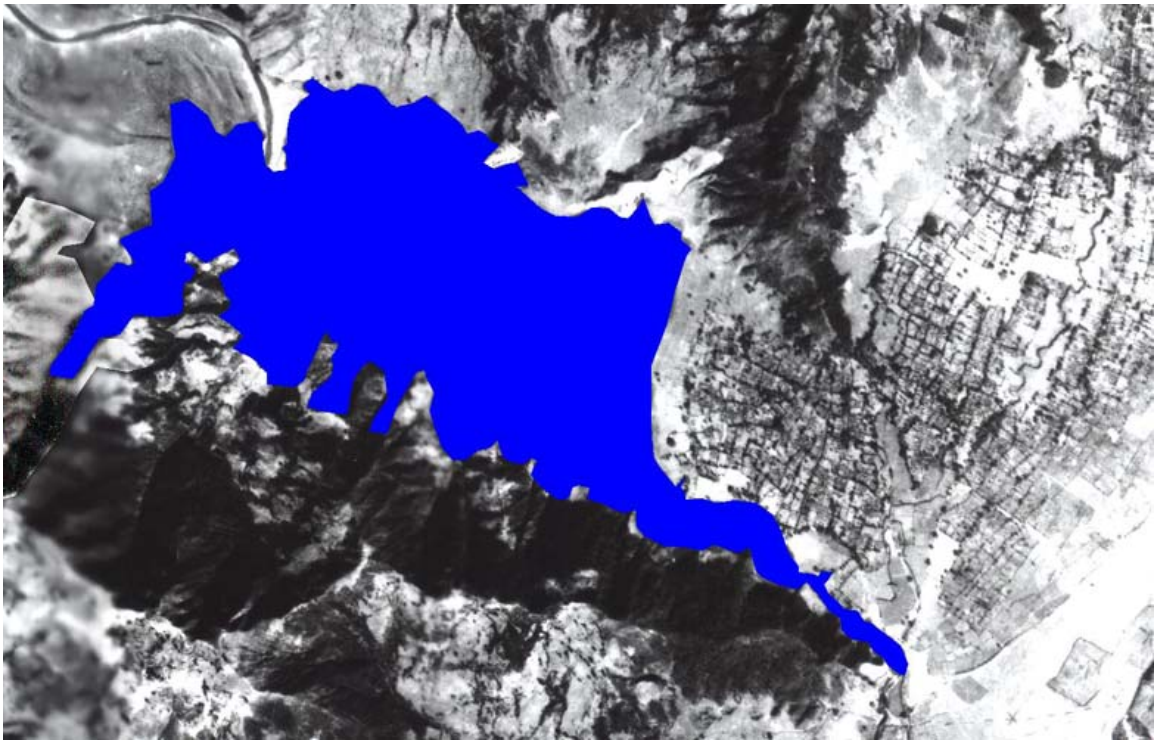

Fig. 2 Aerial photograph of Phewa lake and nearby area taken in 1954 (water body has been marked with blue for clarity)

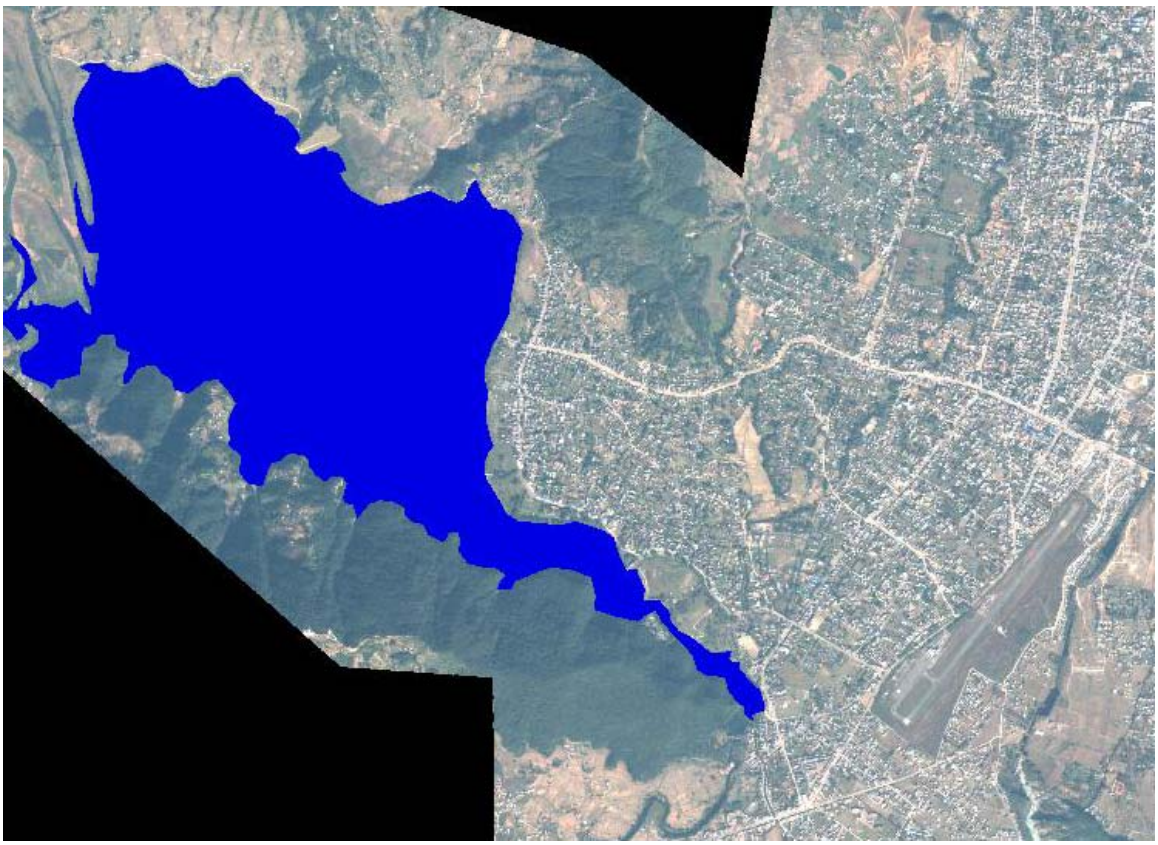

Fig.3 Quickbird image of Phewa lake and Pokhara area acquired in November 2004 (water body marked in blue for clarity)

The Phewa lake is surrounded by hills on all three sides (except on the east, where there is Pokhara city), and the reduction in size of the lake can be attributed to soil erosion and the resulting siltation in the lake coming from the Harpan Khola river that feeds into the lake. Similarly, the quality of lake water is deteriorating because of the significant wastes from the city area being dumped into the lake. The population of Pokhara city has increased

rapidly over the last fifty years as shown in Table 2, and such an increasing population has had adverse impact on the lake environment.

Table 2: Population of Pokhara urban area

Year	Population
1952/54	3755
1961/62	5413
1971/72	20611
1981/82	46641
1991/92	99268
2001/2	183000
2005	225000 (estimated)

Source: Baral (2001); 2005 figure estimated by authors.

6. Conclusion and Further Works

Thus from the studies so far it is demonstrated that the environment of Pokhara area is already affected which is related to the rapid urbanization of the area. The need for effective measures needed for conservation of lakes, by sustainable watershed management and appropriate measures to manage the urban wastes is clearly demonstrated. Such measures have to be taken before it is too late. Further works are ongoing in elaborating the results and generating future scenarios under different policy interventions, which could be useful for making appropriate decisions.

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