Orthophoto Time Series for Environmental Studies in the Kathmandu Valley

Robert Kostka and Viktor Kaufmann

Introduction

The Kathmandu Valley is increasingly confronted with environmental problems that are mainly due to traffic, noise, air and water pollution, waste disposal, population increase, etc. This deplorable situation al-ready proved to be a topic of general concern 25 years ago, when a concept for the physical development of the Kathmandu Valley was developed (Pruscha 1975). Studies on urbanization and population distribution as well as investigations on transportation and infrastructure were recommended, but were realized only to a very limited extent.

Precise basic information is the most important basis for studying the changes that have taken place in the course of the past 25 years. An extensive information system could help to find a solution to the problems the Kathmandu Valley is facing and could pave the way to future sustainable development. Numerous publications indicate that such investigations are of paramount importance not only for the physical environment but also for the Hindu cities of Kathmandu, Patan and Bhaktapur (Gutschow 1982), or the vanishing cultural heritage of the area (Schick 1989).

The goal of the project idea "orthophoto time series"

In order to preserve the environment of the Kathmandu Valley, which is home to hundreds of thousands of people, decisive measures concerning soil, waste, exhaust fumes, noise, water supply, and sewage will have to be taken in the very near future. These decisions must be based on a reliable information system that provides exact environmental data. Orthophotos, which provide a geometrically correct representation of the aerial photo content on the basis of a precise terrain model, are very suitable for that purpose. An information system designed to support sustainable development in the Kathmandu Valley must contain data on the past and present situation of the region and must also take future tendencies into account.

The most comprehensive information for this purpose is contained in two series of aerial images of the Kathmandu Valley taken in 1971 and 1992. Both photo series were taken in panchromatic mode. It is very difficult, sometimes even impossible, to compare their information content due to different flight lines and image scales. This basic photo material must therefore be transformed to geometrically correct orthophotos at the same scale and in the same reference system to render them suitable for comparative studies.

The basic sources for orthophoto preparation

The aerial photos dating from 1971 were taken by the well-known Austrian mountain cartographer Erwin Schneider within the framework of the Association for Comparative Alpine Research in Munich. The specifications of these photos are:

Aerial images of the whole Kathmandu Valley, December 13, 1971
Image format: 24 x 24 cm2
Camera, focal length: WILD RC 10,
c=152,37 mm
Image scale: approx. 1:20 000
For the location of the images see flight line index 1971 (figure 1).

These images were originally used to prepare maps of the Kathmandu Valley at scales of 1:10000 and 1:50000 (Assoc. for Comp. Alp. Res. 1977). The 1:10000 map series consists of 16 sheets, each sheet covering an area of 56 km^2. The contour interval is 10m.

In 1992 the Topographical Survey Branch HMG, Kathmandu, also took aerial images of the whole Kathmandu Valley. The following specifications are presently available:

Image format: 24 x 24 cm2
Camera, focal length: ?
c = 153,19 mm
Image scale: approx. 1:50000
For the location of the images see flight line index 1992 (figure 2).

The two existing series of aerial images, together with collateral information, e.g. geodetic coordinates and map sheets at scales of 1:10000 and 1:5 000, provide an excellent basis for the preparation of the orthophoto time series mentioned above. The terrain information for generating the digital elevation model (DEM) is given by contour lines at intervals of 10 m.

Pilot study in the Bhaktapur test area

For the city of Bhaktapur and its surroundings two digital orthophotos were prepared in order to study the environmental changes (settlements, buildings, road network etc.), which have taken place in this region since 1971. A scale of 1:10000 was chosen, which could be subject to changes in the digital format. The medieval Hindu city of Bhaktapur was selected as the test site, being a place which has not been greatly affected by westernization until the beginning of the seventies (Gutschow, Kölver 1975). At that time agriculture was the main source of income in Bhaktapur. As could be observed in the aerial photos this situation in the surroundings of the ancient city has changed.

The location of the orthophotos is given with reference to aerial images 2538 (1971) and 35-21 (1992). The control points and the terrain information (DEM) were derived from the 1:10 000 Kathmandu Valley map. The aerial images were scanned with a resolution of 25 µm, which was followed by digital orthophoto preparation using the GAMSAD software package. The ground

pixel size in the two orthophotos is 1 m2. The subsequent cartographic work was done with CorelDraw 6. The pilot study resulted in two orthophotos dated 1971 and 1992 (see attachments) in digital format (CD) and as paper prints.

Experience in the preparation of digital orthophotos in mountainous areas and the knowledge of the potential of optical-photographic image data were a prerequisite for the investigations (Kaufmann et al. 1994). The image maps, referred to the reference system of the 1:10000 Kathmandu Valley map, show the information content of the panchromatic photos and cover an area of 3.5 by 1.5 km2. The quality of the orthophotos is slightly reduced due to the fact that the photos were taken in different seasons and at different original scales. But nevertheless they can serve as important geometrically correct basic information for many tasks.

Potential and use of the cartographic representations

The black-and-white orthophoto maps at 1:10000 scale are not a final cartographic product, because they do not contain names, contour lines or other details. But they can serve as a useful and important tool for a wide range of environmental studies. They represent an intermediate link between very large-scale photographs from terrestrial points or helicopters (Kostka 1992) and spaceborne remote sensing data (Haack et al. 1997) used for the mapping of urban areas. They are a useful basis for thematic maps focusing on settlements, traffic lines or agricultural areas in connection with topography and landownership (for the example of the village of Thimi see Müller-Böker 1987). They also can be used for erosion studies, such as the one performed for the Bagmati river in the south of the Kathmandu Valley (Buchroithner, Kostka 1991). However, they are still best suitable for planning processes aiming at sustainable success. The ancient cities of the Kathmandu Valley are growing and the villages are increasingly turning into urban-like settlements. Compared with the situation in the seventies (Haffner 1981/82) interests of people have changed, the basis of traditional life in agricultural surroundings is moving towards industry, business and tourism, thus creating a lot of problems in its wake.

Water supply should be mentioned as an example. Each year the Bagmati river is nearly dry for many months, and its water is dirty and foul. The water reserves of the valley are increasingly being used for industrial purposes and are therefore getting scarce. The groundwater is polluted and poses a serious health risk to Kathmandu residents and visitors (AGSO 1997). Future environmental activities must therefore include water reserves in ponds or the implementation of groundwater protection and control strategies.

Orthophotos of the past and present situation are of essential importance for solving these problems in a regional context.

Concluding remarks

In accordance with the project goals the orthophoto time series should be made available to a wide range of institutions interested in carrying out environmentally and socially significant investigations in the Kathmandu Valley. Therefore the production of these orthophoto maps for the whole Kathmandu Valley is strongly recommended. University institutes or research institutions should also get the opportunity to base their investigations on existing orthophotos for the good of the population of the Kathmandu Valley. Moreover, new aerial photos should be taken in order to continue the research efforts in this field. The terrain model required for orthophoto production can also serve as a basis for these future images, thus paving the way to a wide variety of modern forms of representation, such as animation or transposition, and providing detailed information urgently needed for purposes of environmental monitoring.

Figure 1: Flight line index 1971 and overview of 1:10 000 map sheets
(© Cartoconsult Austria 1996 V. Kaufmann, R. Kotska).

Figure 2: Flight line index 1992 and overview of 1:10 000 map sheets
(© Cartoconsult Austria 1996 V. Kaufmann, R. Kotska).

References :

Association for Comparative Alpine Research
1977, *Kathmandu Valley Maps 1:10 000 and 1:50 000.* Munich, GEO-Buch Verlag.

Australian Geological Survey Organisation
1997, "A successful conclusion to the Kathmandu Valley ground water pollution study", *GEO International*, 6, pp. I-1, I-2.

Buchroithner, M. F.,& Kostka, R.
1991, "Application of remote sensing to geomorphological studies of the Bagmati Valley south of Kathmandu, Nepal", *Mountain Research and Development*, Vol. 11 (4), pp. 281-294.

Gutschow, N.
1982, *Stadtraum und Ritual der newarischen Städte im Kathmandu Tal.* Stuttgart, Verlag W. Kohlhammer.

Gutschow, N., & Kölver, B.
1975, *Bhaktapur — Ordered Space, Concepts and Functions in a Town of Nepal,* Wiesbaden, Kommissionsverlag Franz Steiner GmbH.

Haack, B., Craven, D., & McDonald, J.
1997, "Processing techniques for mapping urban growth: Kathmandu, Nepal", *GeoCarto International*, Vol. 12 (1), pp. 5-12, Hong Kong.

Haffner, W.
1981/82, "The Kathmandu Valley, a Study in Regional Geography", *Journal of the Nepal Research Center*, Vols. V/VI, pp. 3-26.

Kaufmann, V., Klostius, W.,& Benzinger, R.
1994, "Topographic Mapping of the Volcano Nevado Ojos del Salado using Optical and Microwave Image Data", pp. 47-59 in *Proceedings of the 3rd International Symposium on High-Mountain Remote Sensing Cartography*, Mendoza.

Kostka, R.
1992, "Geodetic-photogrammetric work in the course of cultural studies in Nepal", pp. 57-65 in B. Kölver (ed.), *Aspects of Nepalese Traditions*, publication of the Nepal Research Centre, 19, Stuttgart, Franz Steiner Verlag GmbH.

Müller-Böker, U.
1987, "Man, Religion and Agriculture in the Kathmandu Valley", in N. Gutschow & A. Michaels (eds.), *Heritage of the Kathmandu Valley*, pp. 279-293, St. Augustin, VGH Wissenschaftsverlag.

Pruscha, C.
1975, "Kathmandu Valley -the Preservation of Physical Environment and Cultural Heritage", *Protective Inventory*, Vols. 1-2, Vienna, Anton Scholl & Co Publishers.

Schick, J.
1989, *Die Götter verlassen das Land,* Graz, Akademische Druck und Verlagsanstalt.