Topographic Base Map Update in Nepal: Overview, Accomplishments and Way Forward

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KEYWORDS

Topographic Base Maps, Survey Department, ZY-3, Image Processing, Feature Update, Map Compilation, Map Validation

ABSTRACT

The latest series of topographic base map of Nepal were prepared by Survey Department of Nepal during 1992-2001 A.D and preparation of their digital database namely National Topographic Database started in 1999 A.D. Understanding the utmost need of updating these maps and database, the department started update process in a rapid pace from fiscal year 2075/76 B.S based on ZiYuan-3 Survey and Mapping (ZY-3) satellite images with 2.1 m panchromatic and 5.8 m multispectral spatial resolution. The overall update procedure includes satellite image processing, feature update, field verification, field data compilation, finalization, map and database approval from Mapping Technical Subcommittee and finally map reproduction. The technical aspects of this whole process is based on standard specification document namely "Specifications for 1:25000 and 1:50000 Topographic Base Maps". First level of update and field verification of all grid sheets covering Nepal was completed by fiscal year 2078/79 and is now in the phase of approval by Mapping Technical Subcommittee and reproduction. At the end of 2079 B.S, around 250 number of sheets have been approved and are made available by the department. With the completion of this update series, there are further opportunities to produce thematic data/maps as well as administrative maps of smaller scales. Furthermore, with the availability of higher resolution images through LiDAR, UAV and other resources, the department has opportunities to work on large scale mapping in coming days.

1. INTRODUCTION

In Nepal, topographical base maps were prepared by Survey of India (SOI) for the first time during 1950s and 1960s at the scale of one inch to a mile. However, these maps were not updated later and therefore do not represent the current topographical scenario of the country (Shrestha, 2021). Later in 1993, with the technical and financial assistance of Government of Japan through Japan International Cooperative Agency (JICA), Survey Department of Nepal published 81 sheets of topographic base maps covering Lumbini Zone at the scale 1: 25,000 using aerial photographs of 1990 (Pradhananga, 2003). These maps were produced in five colors namely red, green, blue, brown, and black.

Topographical base maps for the rest of the 13 zones were prepared in two projects namely Eastern Nepal Topographic Mapping Project (ENTMP) during 1992-1997 and Western Nepal Topographic Mapping Project (WNTMP) during 1996-2001. 255 map sheets in a scale of 1:25000 for terai and middle mountains and 37 map sheets in a scale of 1:50000 for high mountains and himalayan region were prepared using aerial photographs of 1992 during ENTMP while WNTMP published 254 map sheets in a scale of 1:25000 for terai and middle mountains and 79 map sheets in a scale of 1:50000 for high mountains and himalayan region using aerial photographs of 1995-1996 (Shrestha, 2009). These maps were prepared by Survey Department with technical and financial support of Government of Finland through Finnish International Development Agency

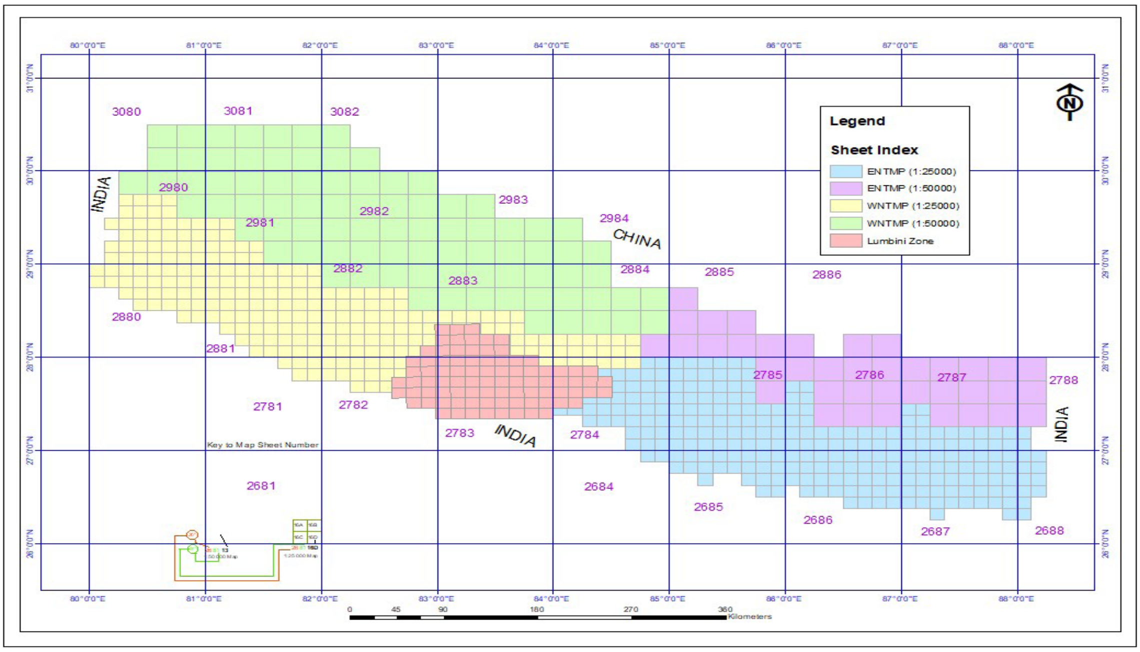

Figure 1: Topographic Mapping Series of Nepal with Sheet Index
(Data Source: Topographic Survey and Land Use Management Division)

(FINNIDA). The contents of these maps were depicted in six different colors (red, blue, green, yellow, brown and black).

In total, 706 maps sheets covered the whole Nepal including 590 sheets in 1:25000 scale and 116 map sheets of 1: 50000 scale in Modified Universal Transverse Mercator (MUTM) projection system. Figure 1 shows the topographic mapping series of Nepal with details of sheet index. These topographical base maps included different natural and artificial features, which can be classified into the point (triangulation point, transmission tower, buildings, temples, hospital, schools, etc.), line (roads, transmission line, contours, streams, administrative boundaries, etc.) and polygon features (land cover) in the context of digital mapping. In addition to these, annotations were added to make the maps more meaningful and readable. Furthermore, in January 1999, Survey Department started digitization of all 1:25000 and 1:50000 scale topographic maps to create National Topographical Database (NTDB) (Shrestha, 2021). These datasets and maps are still in use since their updating process is not yet complete. Since some map sheets were common in Lumbini Zone mapping project and WNTMP, there are altogether 682 grid sheets (563 grid sheets of 1:25000 scale and 119 grid sheets of 1:50000 scale) covering whole Nepal in present topographic base map update series.

2. NEED FOR UPDATE

Updating of topographical maps is directly related to the extent of development activities in the given area. It means the more the developments in a given area, the more outdated are the topographic maps of that area. With the change in time, it is obvious that there have been changes in features that are included in these base maps. Therefore, all the users of topographic base maps from decision makers to researchers naturally expect the updated maps to fulfil their purpose. Moreover, the updated maps depict the changing scenario likes decreasing agricultural lands, densification of residential area, proportion of development in different regions, availability of infrastructures and so on. Hence, regular updating of these maps is undoubtedly, most essential at present to address all the activities that rely on using Topographic maps.

Survey Department started updating the topographical base maps in a rapid pace from fiscal year 2075/76 B.S. based on ZiYuan-3 Survey and Mapping (ZY-3) satellite images. These images are provided in free of cost by Land Satellite Remote Sensing Application Center(LASAC), China based on MOU (in 2018) between LASAC, Ministry of Natural Resources of P.R. China and Government of Nepal, Ministry of Agriculture, Land Management and Cooperatives, Survey Department to provide satellite image till 2023. The ZY-3 (Ziyuan-3, 'Resource-3') series represents China's first high resolution, stereoscopic mapping satellites for civilian use with 2.1 m panchromatic and 5.8 m multispectral spatial resolution (Wang, *et al.*, 2013). The images are, in general, in WGS84 UTM coordinate system.

Before this, some efforts were also made to update the maps in eastern region of terai. However, without the standard specifications for updating the maps digitally, final results were not achieved. In FY 2075/76 B.S, preparation of standard specification for topographical base map update and field team mobilization for data collection and verification were conducted simultaneously and the standard specification document namely **"Specifications for 1:25000 and 1:50000 Topographic Base Maps"** was later approved from Mapping Technical Subcommittee. With this, all the database has been prepared and corresponding maps have been compiled with reference to this standard specification.

3. OVERVIEW OF TOPOGRAPHIC BASE MAP UPDATE

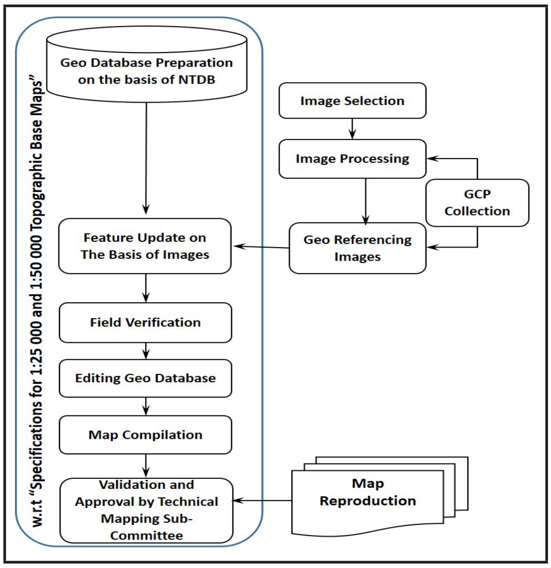

Figure 2: Overall workflow diagram for topographic base map update

For updating the existing topographical base maps, the department has been using ZY3 satellite images to detect changes, to include new features in the original database and/or to remove non-existing features supplemented by field verification and subsequent cartographic works in digital environment. The original digital databases (coverage file format) of topographic map sheets are acquired from the Geographic Information Infrastructure Division (GIID), Survey Department. A sheet wise file geodatabase for each topographic map sheet is then created based on the standard specification document. Thereafter, data from each coverage file is imported to corresponding feature class of corresponding geodatabase for update process. The detailed methodology is explained below and its work flow diagram is shown in Figure 2.

3.1 Image processing

Latest satellite images covering the planned grid sheets area are selected with cloud coverage less than 5% as far as possible from the image database. This includes the corresponding raw panchromatic and multispectral image pairs. Thereafter, Ground Control Points (GCPs) are marked in the images considering the coverage of entire working areas. GPS survey is then carried out in the pre-marked areas in the field following standard procedure. The processed data is then used to transform from WGS 84 coordinate system to MUTM system.

In this stage, each panchromatic and multispectral images are orthorectified using processed GCPs (in WGS84 UTM) collected from Differential Global Positioning System (DGPS), Rational Polynomial Coefficient (RPC) geometry file of satellite image and corresponding Digital Elevation Model (DEM). Both orthorectified panchromatic and multi-spectral images are mosaicked for applicable scenes and then pansharpened to enhance visual image interpretation process. Thus obtained pansharpened image and processed GCP coordinates (in MUTM) are used to obtain the georeferenced image which are then used for feature update process.

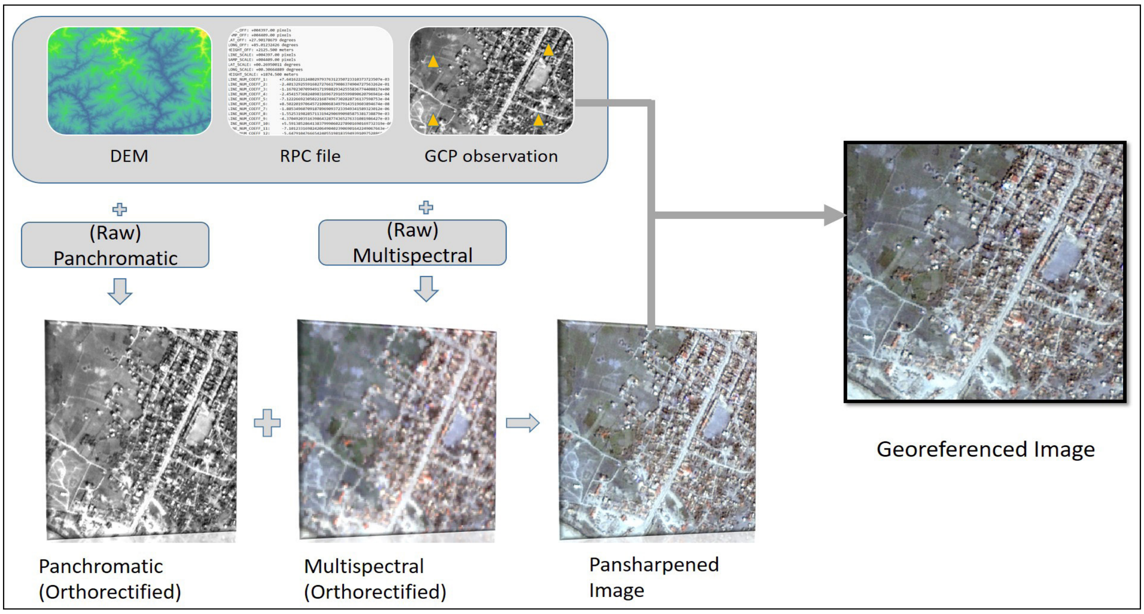

Figure 3: Image processing workflow

3.2 Feature update and field verification

In this phase, on top of georeferenced images, existing feature datasets of base map are displayed. With respect to the satellite image, the existing features are verified and then updated in GIS environment by using on-screen digitization technique. The major features that are updated using images are land cover, transportation network, hydrographic features and building points.

The updated data from the images and the existing database are then verified from field visit and necessary corrections are made. Furthermore, other details of point features such as government academic institutions, government hospitals, service center, health post, police stations/posts, major religious places, etc. are also collected from field visit.

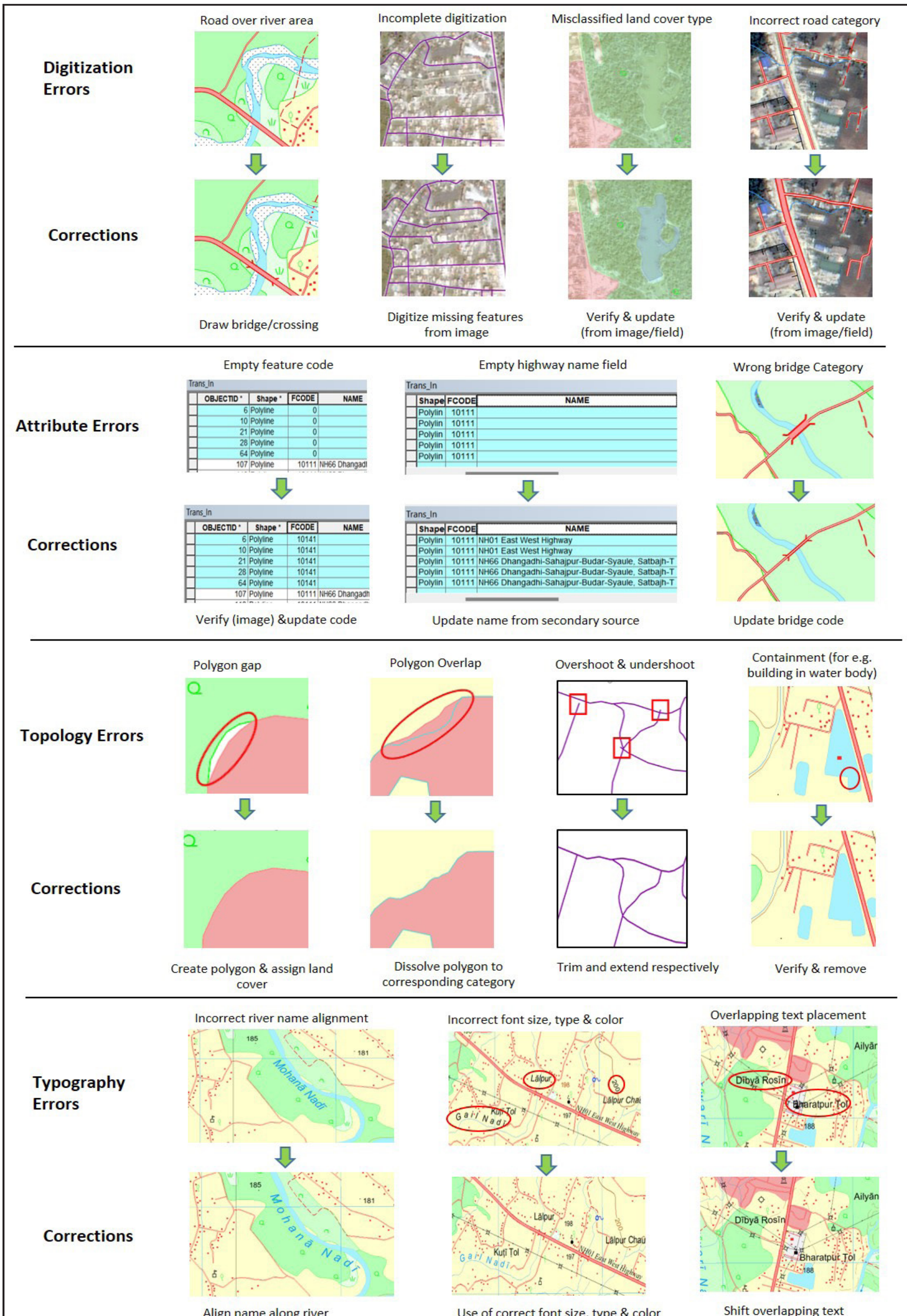

Figure 4: Sample of error types and their correction measure

Apart from these, the team collects additional features, names and other attributes as required. Along with these, for features like transportation (national highways), designated area boundaries, transmission lines and canals, secondary data are collected from authorized sources.

3.2 Field data compilation and finalization

Features are edited and updated after subsequent field verification and are incorporated in the sheet wise database. In case of new added features, corresponding feature code and/or attribute codes are also updated in attribute table with reference to standard specification. Once all the features are updated and verified, topology test is conducted to detect and correct digitization errors. This test ensures the spatial relationship among the features and helps to maintain the topological consistency in data. Besides, several other errors such as errors in database schema, attribute table, typography are identified and then corrected. Figure 4 shows some samples of errors that are mostly identified during data verification phase and their corresponding correction measures.

3.3 Map compilation in digital environment

The basic objective in the map compilation phase is to prepare a composite containing all the reference data, geographical features, text etc. that appear in the map in digital environment. The final edited database is used to compile the updated topographic map. Figure 5 and 6 respectively represent a sample of originally compiled topographic base map and a sample of updated base map compiled in digital environment. The final layout of the compiled map consists of following elements:

3.3.1. Map body

According to the map sheet layout system in Nepal, the map body (the area within the neat lines) represents the ground area of extent 7' 30" in longitude and 7' 30" in latitude in case of map at scale 1:25 000; and 15' 00" in longitude and 15' 00" in latitude in case of map at scale 1:50 000. The features are represented in the map with the help of different symbols viz. point, line and polygon along with the textual notations for required feature label.

a) Use of Symbols and Symbol Levels: All the features shown in topographical base maps are symbolized based on their feature and/or attribute code. Symbol and color description (CMYK values) with their dimension are also listed in standard specification document.
b) Features Hierarchy: For cartographic visualization, feature hierarchy is maintained in order to ensure that all features are visible in final compiled map.
c) Cartographic Generalization: Considering map scale, features are generalized. It includes features simplification, smoothing, aggregation, displacement, omission, exaggeration, enhancement and classification. While displacing the features in need, displacement priority rule is considered.

3.3.2. Map border

This section between the neat line and the map body frame, consists of two map elements; grid and graticule, and destination annotations (nearest destination of the roads).

3.3.3. Marginal information

Marginal information of each map sheet consists of sheet title, sheet number, legend, administrative index, map sheet history, index to sheets, location diagram, edition, map scale, copyright, contour and datum information and pronunciation guide.

3.4 Map and Database Approval and Map Reproduction

In this stage, the final products of topographic base map update i.e. maps and database are presented to Mapping Technical Subcommittee for final approval. Once approved, for low quantity production, the maps are directly printed from the wide format color printer. While in case of mass production, the printing plates are produced directly from the EPS (Encapsulated PostScript) file through Computer to Plate (CTP) machine.

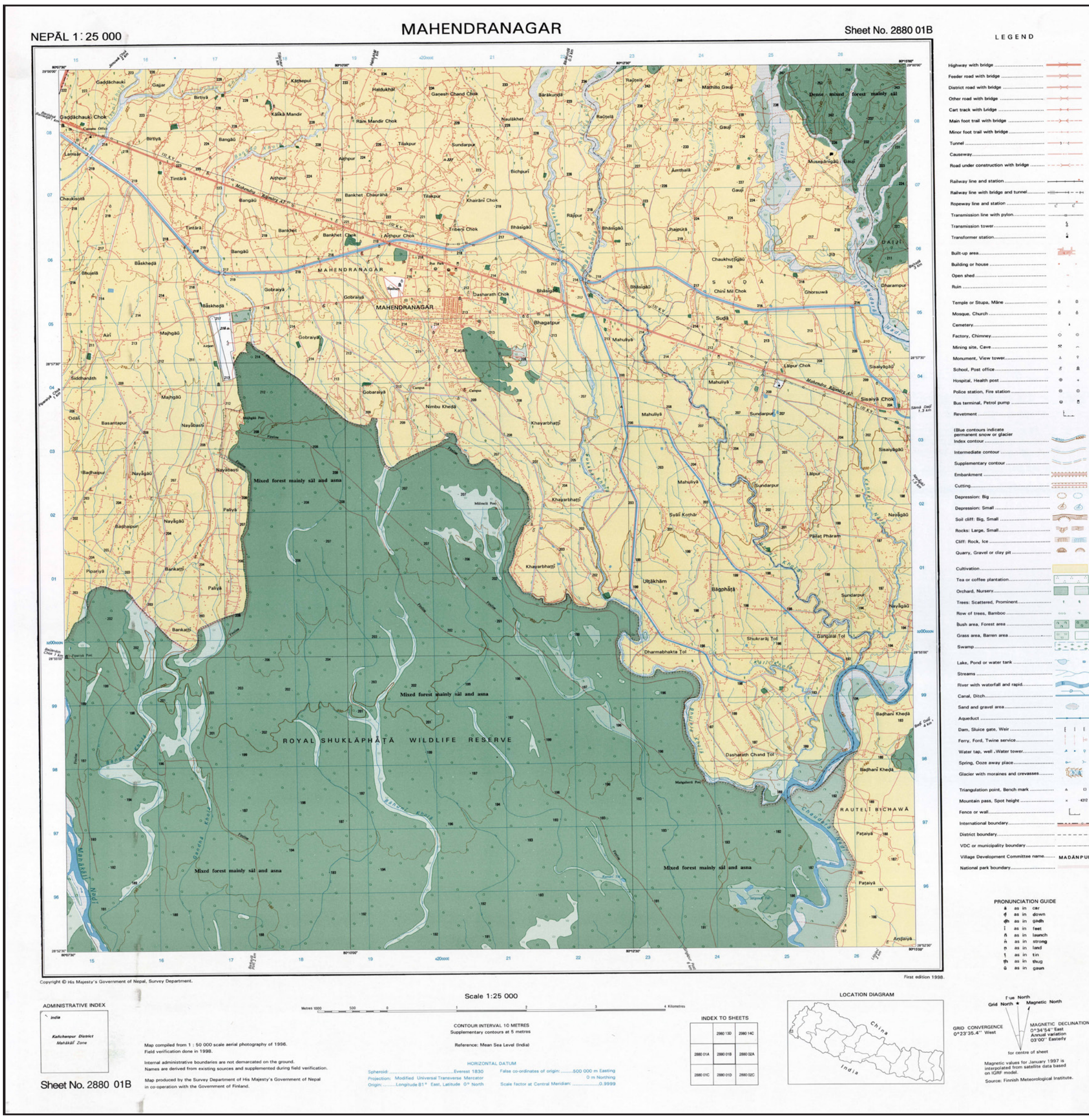

Figure 5: A sample of originally compiled topographic base map (Sheet No: 288001B, Mahendranagar) (Source: Topographic Survey and Land Use Management Division)

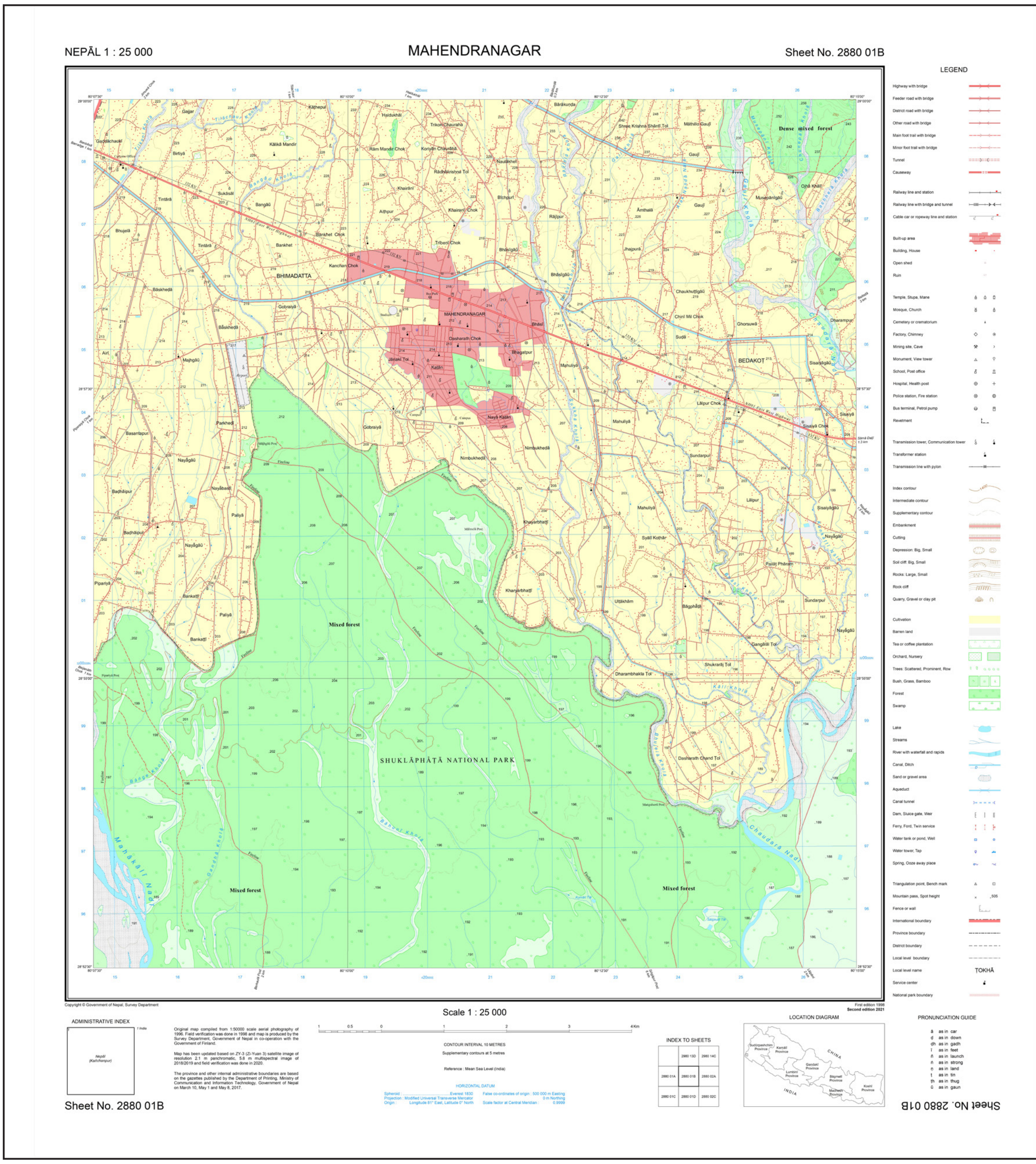

Figure 6: A sample of updated topographic base map compiled in digital environment (Sheet No: 288001B, Mahendranagar) (Data Source: Topographic Survey and Land Use Management Division)

4. ACCOMPLISHMENTS SO FAR

Survey Department started extensive topographic base map update work from fiscal year 2075/76 B.S. which covered almost all of the Terai region of whole Nepal. Then, map sheets covering most of the hilly region of Nepal were prepared by update work in fiscal year 2076/77 B.S. Proceeding update work, remaining map sheets were updated in the fiscal year 2077/78 B.S. and 2078/2079 B.S. Figure 5 shows timeline of topographic base map update series of 682 map sheets from fiscal year 2075/76 to fiscal year 2079/80.

At present, the updated topographic base maps are in the phase of approval by Mapping Technical Subcommittee and reproduction.

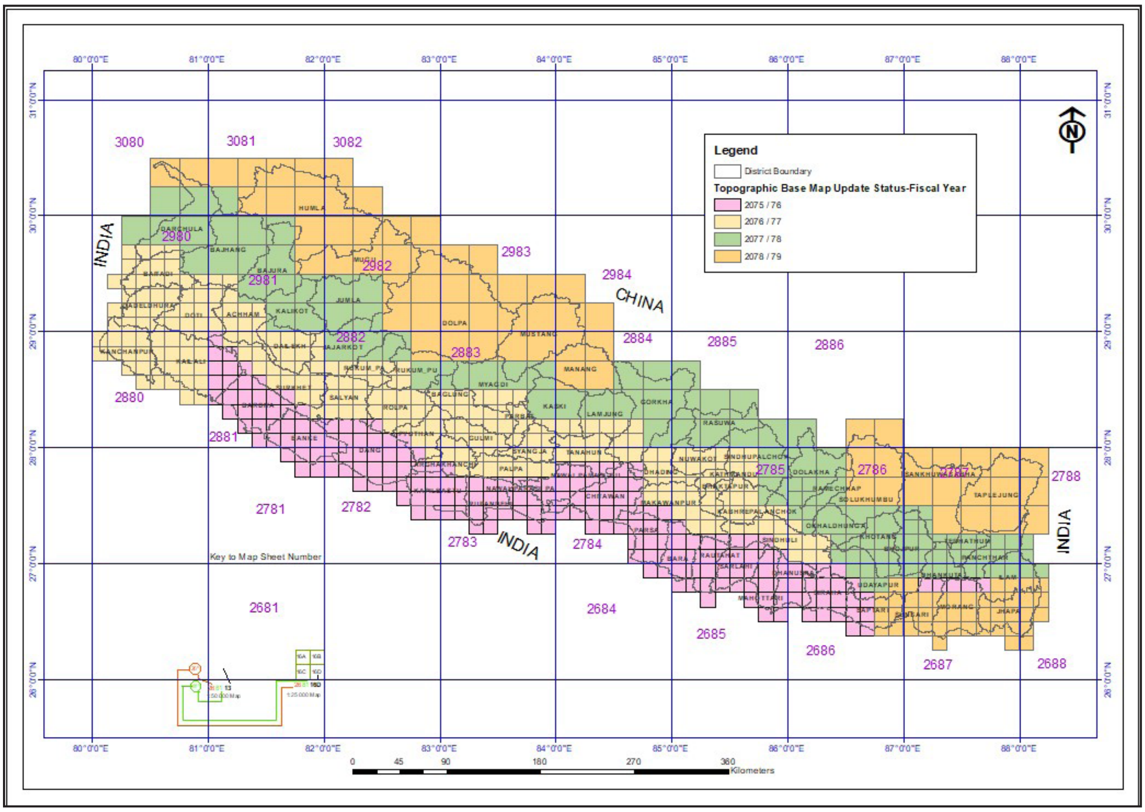

Figure 7: Topographic base map update from fiscal year 2075/76 to 2078/79
(Data Source: Topographic Survey and Land Use Management Division)

At the end of 2079 B.S, around 250 number of sheets (mostly western terai and mid-hill region) have been approved and are made available by the department.

5. CHALLENGES AND LIMITATIONS

Topographic base map update involves a series of desktop and field work with rigorous digitization and verification procedure as explained before and therefore takes time in finalizing both the database and maps. Level of image interpretation and feature update may differ upon human resource and their experience to some extent although they are trained beforehand. Since this is an update process and not a new mapping, it involves more manual work in digitization process which tends to generate errors. It is clear that the major errors/blunders are fixed through several error detection tools however, minor errors may still remain.

The updated features/details are based on used image acquisition date and corresponding field verification date regardless of map print date. During field verification process, features of topographically inaccessible areas of Nepal, are verified and updated from local level representatives. Digital database prepared is based on digital cartographic model rather than digital landscape model. In this case, features are generalized with respect to map scale and thus displacement of features can occur to some extent.

6. WAY FORWARD

Obviously, the first target of the Survey Department is to approve and publish the remaining topographic map series of whole Nepal in the coming days. This will provide a base to generate several thematic data and maps of whole Nepal as well. Furthermore, administrative maps of smaller scale like district level maps can be compiled based on this updated topographic data with further field verification.

At present, the department has been publishing topographic base maps at the scale of 1:25000 and 1:50000. which covers a broader area and lesser detail and mostly useful for regional planning and infrastructure development. On the other hand, large scale topographic base maps not only provide with higher topographic details with better accuracy but also is applicable for infrastructural planning, disaster management and emergency responses, resource management, among others at city/ local level.

With the advancement of technology, availability of higher resolution images from LiDAR, UAV and other resources, and mapping tools and algorithms for automatic and semi-automatic feature extraction, there are opportunities for large scale topographic mapping. Together with this, availability of required infrastructures and resources are mandatory to conduct large scale mapping series

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