APPLICATION OF GEOGRAPHIC INFORMATION SYSTEM (GIS) AND REMOTE SENSING TO LAND ASSESSMENT IN THE PHILIPPINES

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Abstract:

GIS and remote sensing are currently being utilized in the Philippines for assessing various land concerns such as soil erosion, upland utilization and property values. These issues are priorities of the Government because they deal with the single most important national resource, which is land. Three (3) types of GISs are being used (e.g., ARC INFO, TYDAC SPANS and CRIES) in the overlay analysis of attribute maps, produced to a large extent using remote sensing techniques. The resulting decision maps are basic considerations for the effective management of sloping lands, and more importantly, for revenue collection in prime agricultural lands.

Key Words: GIS/LIS, Remote Sensing Applications, Land Applications, Mapping.

1. INTRODUCTION

About 50% of the Philippines' total land area of approximately 30 million hectares is arable. With a population of 65 million, the pressure to open forestlands to agriculture, and to devise ways and means of effectively utilizing available land resources is expectedly great.

There are three (3) main concerns involving land in the country today: determining additional areas for cultivation, preventing further degradation of land resources mainly through soil erosion, and collecting the proper revenue from the citizen's use of the land. Such a wide scope of interest necessitates the use of modern evaluation methods, such as remote sensing and GIS, which could give quick and accurate results.

Practically all of the arable lowland areas are already under cultivation, or are subject to private rights. As a consequence, new sites for agriculture must come from the uplands. This is a very sensitive issue, since forests and watersheds must be protected for obvious ecological and environmental reasons. The delicate task of determining upland areas suited to agriculture, taking into account as many considerations as possible, can be easily accomplished through the use of a computer-based evaluation system, such as a GIS.

The opening up of sloping lands to agriculture, as well as other human activities in these areas such as logging, has the immediate consequence of increasing soil loss through erosion. A secondary effect of this is the accompanying siltation and sedimentation of waterways, continuing onto coastal reef areas. Therefore, the same GIS must be able to address the need to map areas which are susceptible to erosion in various degrees.

Finally, as income is derived from subjecting the land to agricultural and other uses, proper assessment must be made for taxation purposes. In many instances in the country, this effort is hindered by the absence of maps showing property boundaries. Provisional lot plans can, however, be plotted by photogrammetric means, which could then be incorporated into a GIS.

These photo-based maps can be the practical basis for tax assessment in many areas in the country where cadastral surveys have not been undertaken. When more accurate maps or lot plans become available later on, the GIS database consisting of digitized photo-based maps could then be easily revised or updated.

This paper presents the techniques used by the various projects of the GIS Applications Development Division of the National Mapping and Resource Information Authority (NAMRIA), the central mapping agency of the Republic of the Philippines, in applying GIS and remote sensing for land assessment as stated above.

2. DESCRIPTION OF PROJECTS AND THEIR STUDY AREAS

2.1 Determination of Suitable Upland Agricultural Areas

This project was initiated in 1988 with the town of Tuba, in the province of Benguet, as the study area. Benguet has a mountainous terrain, and contains the highest peak in the island of Luzon, Mt. Pulag, whose elevation is about 2,900 meters above sea level. The province is located about 250 kilometers north of Manila.

The project aims to determine which areas in Tuba are suited to agricultural use based on such parameters as slope, soil type, availability of water, accessibility, and existing land use. ARC/INFO GIS was used for this purpose.

2.2 Soil Erosion Susceptibility Mapping

The project also commenced in 1988, with the Tamlang River Watershed, in the town of Brooke's Point, island-province of Palawan, as the study area. Palawan is a long, narrow island located about 300 kilometers southwest of Manila, and is one of the few areas in the country where the environment

is still relatively undisturbed. For this reason, great attention is devoted by the Government in conserving Palawan's natural resources.

The purpose of the project is to delineate different areas in the watershed having various degrees of susceptibility to soil erosion. The GIS which was utilized by the project for this is CRIES, which is based on the Universal Soil Loss Equation (USLE).

2.3 Assessment of Agricultural Resources Thru Photo-Tax Mapping

Initiated in 1989 to assist local governments increase their revenue from agricultural lands, this project is being implemented in three (3) towns: Pagudpud in Ilocos Norte province; and Bulan and Sorsogon, both in Sorsogon province. These towns were chosen based on a number of criteria, foremost of which is the availability of new aerial photography.

Property boundaries are delineated using rectified and enlarged aerial photos as base, and changes in declared ownership, land use and other improvements are noted. These data become the bases for revising and/or updating the tax assessments on the land. The resulting tax maps and tax declarations are then computerized using TYDAC SPANS GIS and Dbase 3+.

Figure 1 shows the location of the study areas for all the three (3) projects mentioned above.

3. METHODOLOGY

3.1 Collection of Existing Data

This is done in order to gather the layers of data required for the GIS. Information on topography, slope, soil type, land use, hydrology and climate/rainfall are commonly collected. Maps showing these are usually available from the appropriate government institution.

Once this step is completed, the data gaps can be determined. Consequently, measures can be adopted to fill in these gaps, such as interpretation of available remote sensing data to extract the needed or missing information.

For example, land use information can be interpreted from both aerial photos and satellite imageries. Distribution of soil types can be accurately mapped from aerial photos when supported by adequate field sampling.

3.2 Preparation of Map Drafts

Since a GIS requires both location and attribute, it is convenient and practical that all inputs should be in the form of maps. Fortunately, 1:50,000 scale topographic maps produced by NAMRIA are available for all parts of the country, and can be used as cartographic base.

Drafts of the different maps are prepared initially, since these usually will have to be updated and/or validated in the field. The medium used is tracing film, and blueprints are made for field mapping.

3.3 Field Investigation

Field visits are made for several reasons. One is to familiarize those involved with the project with the biophysical conditions of the area. Another is to collect data which may be required in the preparation of the various thematic maps. For example, it may be necessary to collect soil samples which will serve as "ground truth" data in the preparation of soil maps.

For tax mapping purposes, extensive field work is undertaken to ascertain property boundaries. This requires visually inspecting and locating markers, also called monuments, and mapping these onto aerial photographs.

3.4 Preparation of Final Thematic Maps

The map drafts are revised or modified manually using field observations. Other required cartographic details are finalized such as legend, scale, coordinates, titles, etc. Colors are also added by hand.

The final maps are produced in single copy only, since the manual cartographic process is tedious and painstaking.

3.5 GIS Data Entry

Data entry is accomplished both by encoding and digitizing map information, depending on the GIS used. Map digitization is commonly practiced for both ARC/INFO and TYDAC SPANS. On the other hand, data encoding is sufficient for the public domain software CRIES.

It is worthwhile to note that the data generated by the three (3) systems are compatible in format.

3.6 Data Analysis

There are three (3) bases for data analysis corresponding to the three (3) application areas: Suitability Criteria, USLE, and the Real Property Tax Administration Code (RPTAC) of the Philippines.

The Suitability Criteria is user-set, and guides the classification of an area into suitability types of high, medium and low. It takes into account slope, soil depth, soil texture, drainage, and soil fertility. Other considerations are existing land use, accessibility and hydrology.

The USLE is pre-set into the CRIES software. Its variables are rainfall and runoff, inherent soil erodibility, slope length, slope steepness, land cover and soil conservation practices.

The RPTAC provides rules for tax assessment of real property in the country. The tax due is a specific percentage of the assessed value, which is the product of the property's area in hectares, market value and assessment level. The assessment level is a certain percentage which is dependent on the nature of the land use.

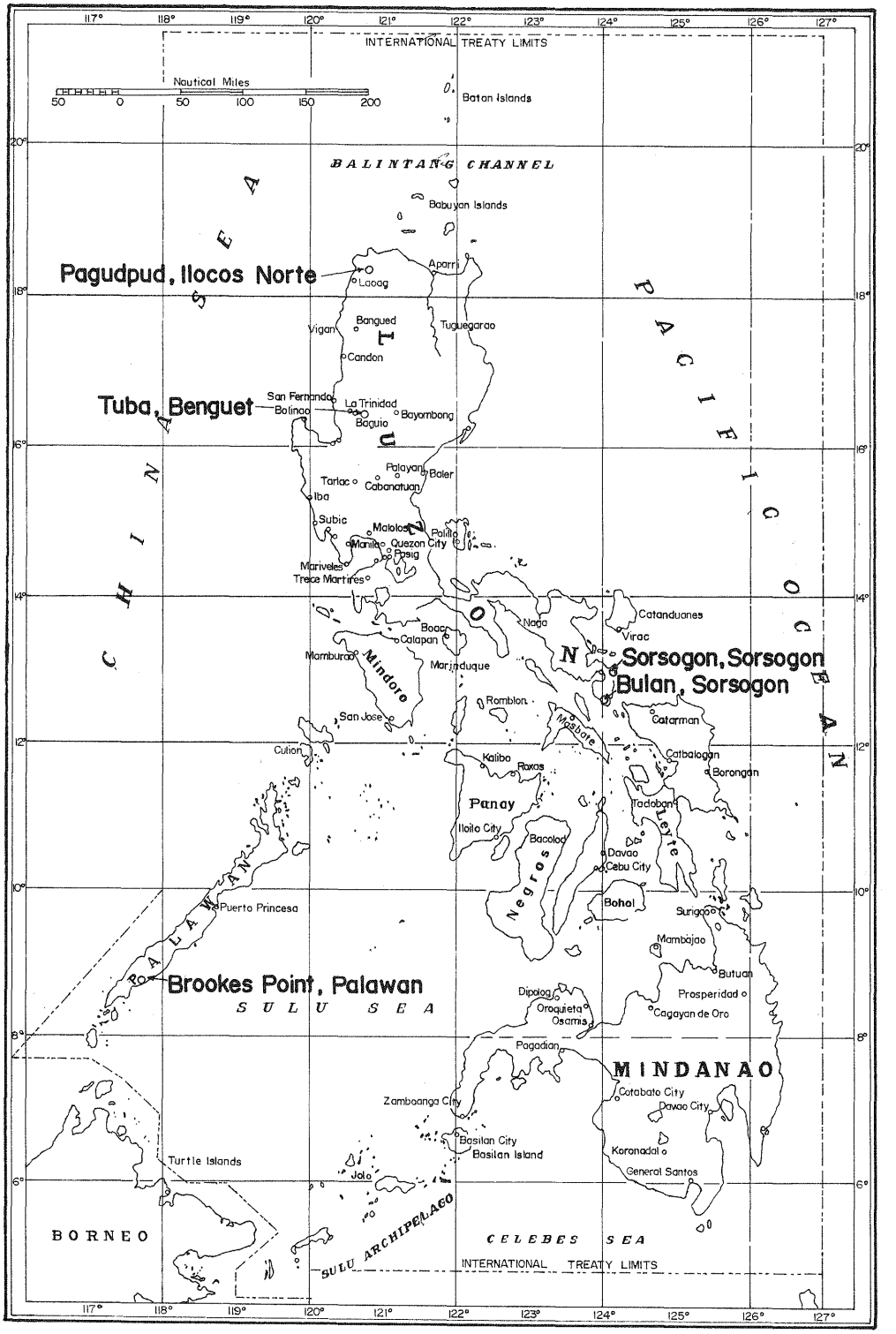

Figure 1. Map of the Philippines showing the three (3) pilot areas for the land assessment studies using GIS and remote sensing.

3.7 Generation of Decision Maps

Once the GIS has analyzed the data based on the criteria stated above, the corresponding decision maps can be generated using a plotter or printer. The design of these outputs can be made directly onto the computer, and the generated maps are already in their final form.

The procedure just discussed follows very closely the operations diagram of the GIS Application Development Division of NAMRIA which is shown in Figure 2.

4. DISCUSSION OF RESULTS

4.1 Suitability Map of Tuba, Benguet

Figure 3 shows the Suitability Map of the town of Tuba in Benguet province. Three (3) classes of suitability to agriculture are shown: high, moderate and low.

Areas identified as highly suitable generally have slopes less than 25%. These have a total area of 1,255 hectares or about 3.50% of the municipality. Areas identified as moderately suitable generally have slopes less than 40%. These cover about 2,349 hectares or approximately 6.71% of the town.

Together, these two (2) suitability classes are characterized by proximity to roads, and medium to low susceptibility to soil erosion/degradation. The rest of the town, comprising of about 31,428 hectares were classified as not suited to agriculture mainly due to their steep or very steep slopes.

Suitability maps of mountainous areas such as Tuba are very important in the management of sloping lands in the country since Philippine law, in general, prohibits the use for agriculture of areas having slopes greater than 18%. However, if there are strong justifications for reclassifying these areas, such as those presented by suitability maps, then they can be "released" officially to the recommended land use.

4.2 Soil Erosion Susceptibility Map of the Tamlang River Catchment in Brooke's Point, Palawan

Figure 4 shows the Soil Erosion Susceptibility Map of the Tamlang River Catchment in the town of Brooke's Point, in the island of Palawan. Three (3) classes of soil erosion susceptibility are shown: slight, medium and high.

The areas identified as highly susceptible to erosion are generally open and denuded steep forestlands, with naturally occurring landslides. The soil loss within these sites are predicted at about 105 - 264 tons per acre per year. About 269 hectares or 2.3% of the catchment area fall under this category.

Areas classified as medially susceptible to erosion are also composed of steep forestlands, but are adequately covered with natural vegetation. The soil loss in this category is predicted to be between 56 - 96 tons per acre per year, encompassing about 444 hectares or 3.9% of the catchment area.

The rest of the basin is predicted to have slight erosion of about 1 - 49 tons per acre per year. This is true for 93.8% of the catchment or about 10,767 hectares.

Soil erosion is a major environmental concern in the Philippines, as this contributes heavily to the degradation of the precious agricultural lands. Soil erosion susceptibility maps provide valuable information that can guide the establishment of soil conservation measures and other related activities.

4.3 Photo-based Tax Map of San Isidro, Bulan, Sorsogon.

Figure 5 shows the photo-based Tax Map of a section of the village of San Isidro, in the town of Bulan, province of Sorsogon. The map presents information on property identification, boundaries and ownership.

Figure 6, on the other hand, shows the property index map (PIM) of the same site. This map forms part of the official records of the Municipal Assessor's Office of the town, and is used as the basis for tax assessment. Information on this map is based on the cadastral survey of the village undertaken two (2) years prior to this study.

Comparing the two (2) maps resulted to the following observations:

a. there are major changes in property boundaries and corresponding lot areas;

b. there are changes in ownership; and

c. due to (a) and (b) above, revisions in their official land records and tax assessments are necessary.

Thus, for the purpose of real property tax valuation, boundary maps based on rectified aerial photographs are indeed very useful especially in the absence of updated land survey records. In rural areas in the country, a systematic and accurate means of maintaining land records is vital to the prevention of social unrest, since land is the single most valuable property of the peasantry.

5. CONCLUSION

The foregoing discussions have presented only the initial studies conducted by the GIS Applications Development Division of NAMRIA in utilizing GIS and remote sensing to address current national concerns in land assessment. Other projects dealing with relevant issues in the environment and natural resources, such as flood risk assessment and the establishment of 3-dimensional resource information databases are earmarked for implementation in 1993.

For the current year 1992, NAMRIA continued

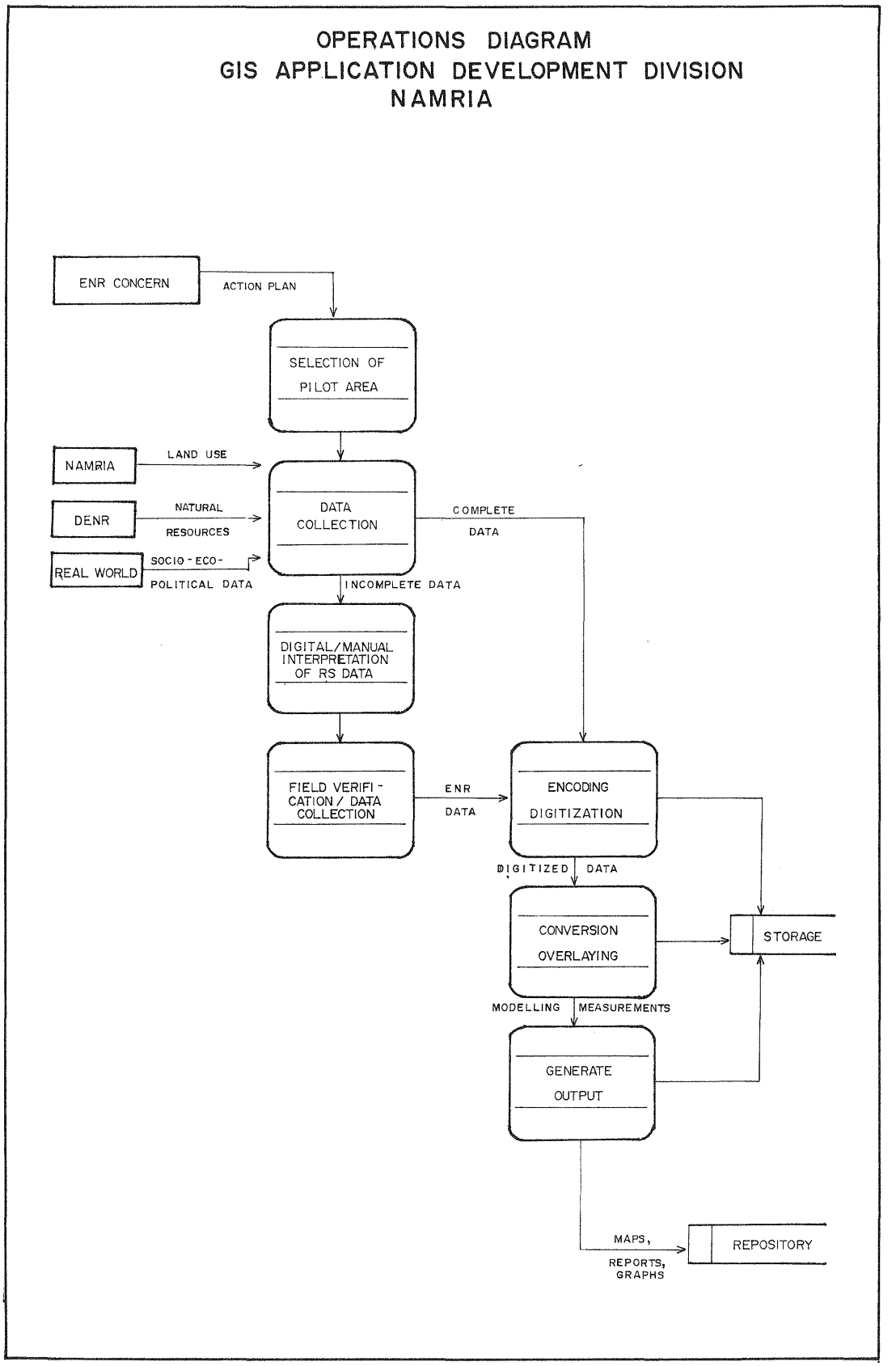

Figure 2. Diagram showing the standard operating procedures of the GIS Applications Development Division of NAMRIA. The methodology used in the land assessment studies follows this diagram.

to implement the three (3) studies just discussed in different areas in order to finetune the computer models used, and validate the initial results. It is important to note that NAMRIA has consciously exerted efforts to involve the local government officials and other relevant local organizations in the conduct of the studies to ensure that benefits accrue to the residents of the study areas. NAMRIA has also initiated steps to transfer some of the technology to the local governments.

The Philippines shall continue to utilize modern technology such as GIS and remote sensing in the protection of the environment and the sustainable development of its natural resources. These tools have time and again proven their usefullness in these fields, and the country have indeed made great strides considering its very limited technical and financial capabilities.

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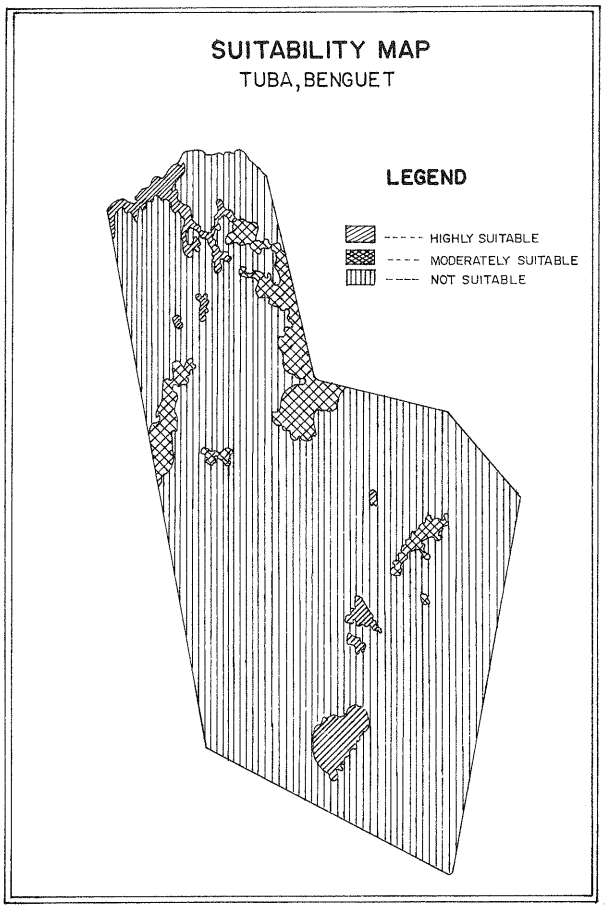

Figure 3. Suitability Map of Tuba, Benguet generated using the ARC/INFO GIS.

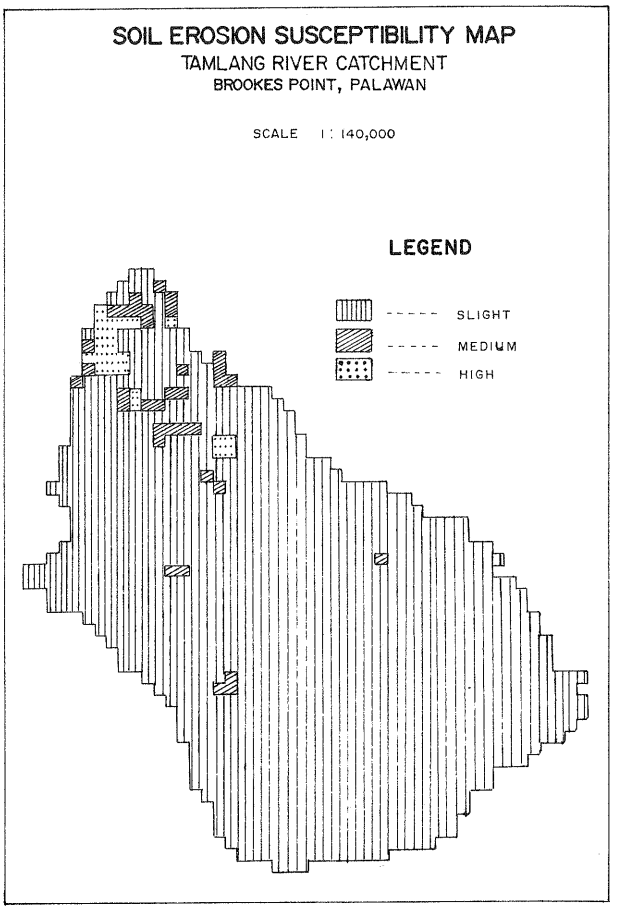

Figure 4. Soil Erosion Susceptibility Map of the Tamlang River Catchment, Brooke's Point, Palawan generated using CRIES GIS.

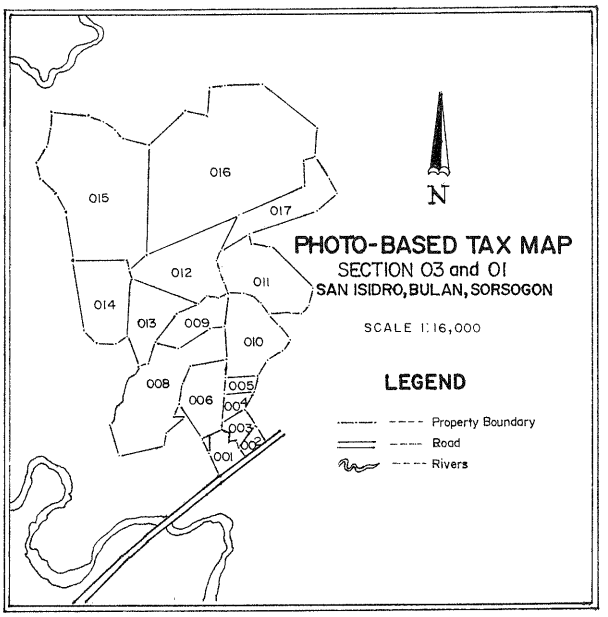

Figure 5. Photo-based Tax Map of San Isidro village in Bulan, Sorsogon produced by delineating actual property boundaries from rectified black-and-white aerial photos.

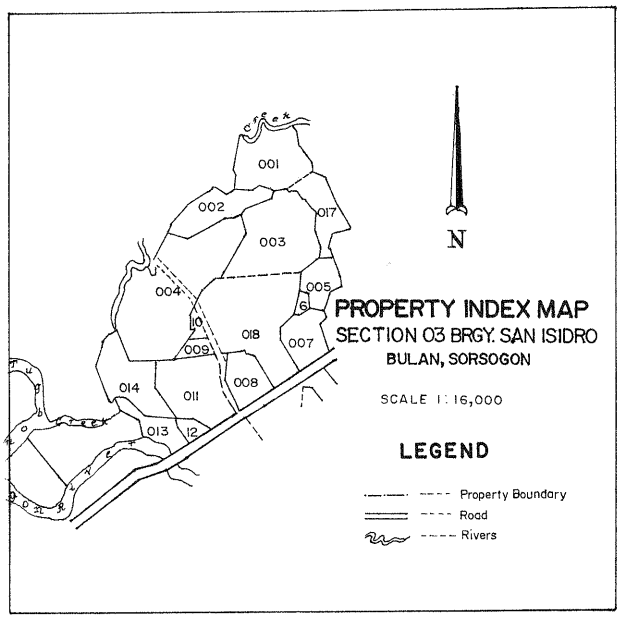

Figure 6. Property Index Map of the same area taken from the official records of the town's Assessor's Office. This map is based on conventional ground survey methods.