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GEOMATICS-ASSISTED IMPACT ASSESSMENT OF LANDUSE CHANGE ON THE BIODIVERSITY OF MT MAKILING, PHILIPPINES

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ABSTRACT

The Philippines has recently been declared by conservationists as a mega diverse country. This biodiversity label is essentially a two-edged sword. On one hand, the designation of the country having the richest diversity on a per area basis emphasizes the urgent need for a multisectoral effort in maintaining and sustaining this richness. On the other hand, this richness has deteriorated to a dangerous level earning us the tag – hotspot.

This paper proposes some important considerations for a sustainable management and monitoring of biological diversity within a geomatics framework. The urgent need for a comprehensive treatment of geospatial technology as a tool for biodiversity conservation is emphasized. This includes a proposal for the establishment of a digital infrastructure that will allow for geospatial processing and analysis, and more importantly monitoring of landuse change as it affects biological diversity. In addition, some research and development issues related to geographic information assessment and analysis are listed. The paper derives from research efforts focusing on the following: standardization, accessibility, accuracy, accountability and integration.

Mt. Makiling is a well-studied and well-researched ecosystem. However, there has been no significant attempt at gathering and organizing these studies into a digital database that would allow an integrated approach for sustainable management. In terms of application of geospatial technology, few studies have been made mostly as part of a thesis research study. Moreover, the focus has been in isolated and limited portions of Mt. Makiling. At the same time, there are differences in terms of resolution. All of these efforts have to be integrated into a management information system for Mt. Makiling. The establishment of a digital infrastructure, through an MIS, is made more urgent with the recent proclamation of the municipality of Los Baños, where Mt. Makiling sits and the seat of the science and research community, as a science and nature city.

INTRODUCTION

Based on the year 2000 census, the Philippine population was estimated at 76.3 million with a rate of increase pegged at 2.5%. Of this number, about 20 million are estimated to live and depend on the uplands for their livelihood. Currently, less than 1 million hectares of natural forest remain in the country. According to Revilla, et al (2000), of the country's total area of 30 million hectares, forest cover was more than 90% in 1575 (see table 1). As of 1995, only 18% of the country's land area (or 5.4 million hectares) remains forested out of 15.88 million hectares of *declared* forestlands. Of this amount, the old growth forest is a dismal 800,000 hectares (see Table 2). Add to this the more than ten million hectares which are a combination of brushlands, open and other uses which are most likely without forest cover.

Year	Remaining Forest Cover (Million Hectares)
1575	27.5
1920	18.7
1934	17
1967	10.4
1972	10.1
1980	7.4
1987	6.7
1995	5.4

Table 1. Trail of forest destruction in the Philippines

The problem of forest destruction is directly related to loss of biodiversity (Figure 1). While policy and regulatory instruments may exist, the fundamental issue is the lack of reliable land cover statistics on areas requiring rehabilitation; areas that exhibit high biodiversity conservation value; and more importantly, areas where proliferation and encroachment of people have occurred. On the ground, the increase in cultivated areas vis-à-vis population increase is quite evident, but no data is available that would confidently inform policymakers about the extent of such social intrusion into the forest.

Obviously, the forestry crisis in the Philippines boils down to inadequacies in policies, programs and strategies. Even assuming such instruments are adequate, the basis (i.e. data) for these is far from reality. While the influx into the uplands is staggering, people find out that there are in fact limited livelihood opportunities in these areas. The only quick source of income is to illegally cut/harvest forest resources, especially timber to place a few days' worth of food on the table.

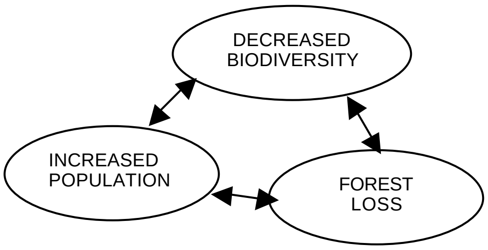

Figure 1. Cycle of environmental degradation

IMPACT OF LANDUSE CHANGE

Mt Makiling, Philippines is regarded as the best-known biological area in the Philippines owing much to its scientific history. It is often cited as having more species of woody plants than the entire United States of America. Within Mt Makiling is the 43 km^2 Makiling Forest Reserve (MFR) under the jurisdiction of the University of the Philippines Los Baños. Although primarily designated as a training and scientific laboratory for the natural sciences, Mt Makiling is also a significant watershed for the surrounding communities, an important catchment for Laguna de Bay – the largest freshwater lake in Southeast Asia, a popular ecotourism site, and a resource rich in biodiversity. Mt Makiling is, however, virtually an 'island' surrounded and continuously threatened by a vast sea of rapidly expanding human settlements, agricultural croplands, and urban and industrial zones (Fernando, et al, 2001). The long-term viability of the ecosystem services that Mt Makiling provides is ultimately dependent on its continued protection and the sustainable use of its resources. This situation is typical on a national scale where anthropogenic pressures are continuously defacing the natural landscape and ultimately degrading the rich biodiversity of the country.

There has been no significant attempt at gathering and organizing studies on tropical forests and mountain ecosystems into a comprehensive compilation of plant species and physiographic data and information that would allow an integrated approach for sustainable management. In most cases, the focus has been in isolated and limited portions of such ecosystems. At the same time, there are differences in terms of resolution, scale, model used and time. All of these efforts have to be integrated to discover gaps and get a more or less complete picture of the current and desired situations (e.g. phylogenetic interpretations, species interactions, hierarchical classifications, ecological functions, landuse change, etc.). Ultimately, it will enable scientists and policy makers to develop and formulate, respectively, appropriate measures to sustain the protective and productive functions of tropical forests and mountain ecosystems.

Table 2 shows the landuse change covering six (6) time periods within the Makiling Forest Reserve for forest, special use and agroforest areas. Before 1992, only tabular data were available and it was only in 1992 that GIS processing was implemented for MFR. Forest areas are represented by second growth dipterocarps and plantations including the tropical rainforest park and botanic garden. Special use areas include the campus, research institutes and outdoor recreation resorts located inside the Reserve. Agroforest areas are those where annual crops and fruit trees along with woody species are grown. Note the stabilization of total area computation from 1992 onwards owing to GIS implementation.

Comparative analysis of forest and agroforest areas reveal that there has been a steady decrease of forest cover and a corresponding increase in agroforest areas from 1979 until 1997 (Figure 2). In addition, Figure 3 shows the landuse change pattern for three time periods: 1992, 1997 and 1999.

YEAR	1968	1979	1989	1992	1997	1999
Forest	1999	2505	2471	2387	2126	2305
Special use	49	400	400	165	165	168
Agroforestry	1757	1339	1373	1795	2055	1874
TOTAL	3805	4244	4244	4347	4347	4347

Table 2. MFR landuse change

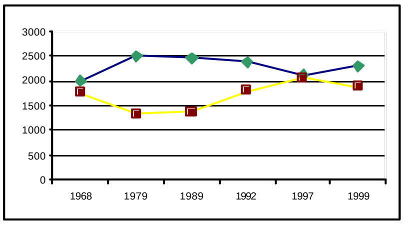

Figure 2. Chart of landuse change in MFR

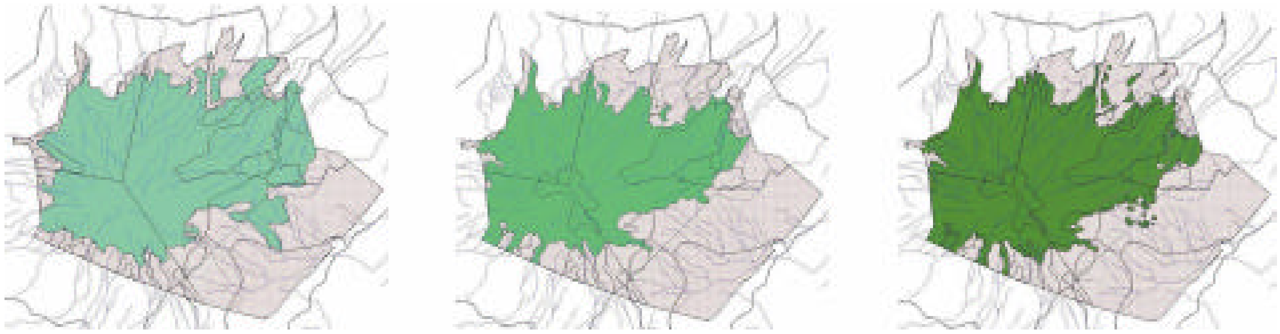
(a) (b) (c)

Figure 3. Landuse change for three time periods: (a) 1992; (b) 1997; and (c) 1999

There is a rich tapestry of research on the different aspects of biodiversity and landuse change dynamics. GIS and remote sensing technologies reveal the impacts of landuse change on the biodiversity of the Reserve. The example given clearly shows the concentration of agroforestry on the south-southeast portion of the Reserve. Some studies show, however, that agroforestry practice exhibit satisfactory levels of biodiversity even higher at some point than forest cover. While these results are promising and good news for social foresters including agroforesters not to mention anthropologists, deeper studies into its impact on ecosystem functions over a long term needs to be investigated. In addition, several important research and development issues on the use of geomatics for biodiversity conservation and natural resources conservation in general can be identified. These are outlined in the following section.

RESEARCH & DEVELOPMENT ISSUES

Standardization

The issue of a standardized reference base for forestry and natural resources necessitates a common terminology that facilitates planning of sustainable and environmentally sound landuse systems at different levels of detail. This includes the ability to translate between existing classifications that contributes to the long-term strategy of food security and resource management (FAO, 1998). The development of a common reference base allows for assessment and analysis of the landscape regardless of the source or location. Standardization refers to the harmonization of mapping activities that will facilitate the exchange of surveyed and mapped information thus eliminating duplication and improving the topicality of maps and associated databases.

Accessibility

On an operational level, tools for resource management must be able to address concerns at the farm level. This view illustrates the multi-level approach to modeling of systems – global, regional, national, and local/farm levels. For instance, the Kyoto Protocol prescribes certain levels of industrial deceleration from the richer countries to address the impacts of global change on the less developed economies.

There is still a long way to go before GIS trickles down to the farm level. Currently, forecasting of production is still very much dependent on the farmers' own experiences. In the future, agricultural productivity will benefit from models derived from the simulation of weather patterns, temperature, humidity, and other parameters important for agricultural production previously inaccessible to the farmer.

Accuracy

Research on accuracy of databases and mapped products is essential to address error. Error propagation is one such research focus. Without a rigorous statistical procedure to illuminate the integrity and quality of data, the final product will essentially contain the original errors from which they were gathered or derived. And depending on the number of overlay analyses conducted, the errors will consequently increase or propagate.

While there are traditional statistical methodologies available in practice, basic procedures must be put in place to generate alternative procedures for accuracy assessment.

Accountability

The issue of accountability is probably more difficult to tackle as a research issue and it is closely related to the discussion on accuracy. Products derived from geospatial technology are increasingly being used and traded commercially. Surveying and mapping companies continually boast of using GIS, remote sensing and GPS in their products. A number of GIS software is available in the market with its own algorithms and operations. Remote sensing images can come from a number of sources using various sensors. The sources of these data and images are usually blurred as the final products are sold in the open market. Who is accountable when disasters occur resulting from analysis derived from geospatial technology? The source of raw data? The GIS company? Or the end-user?

Integration

Sustainable development is inconceivable without strong links between the physical, biologic, social and economic sciences (Bie, 1997). This necessity for strong linkage stems from the continuous lack of fundamental knowledge about the biophysics of the landscape, the inability of scientists to communicate with the farmers' own knowledge systems and the farmers' physical and economic inability to implement these knowledge systems. The development of integrative models that are able to address in a more or less hierarchical manner resource allocation and location problems is an area of research that deserves the full attention of the scientific community. Such models must be able to deal with the complexity of the decision problem considering multidimensionality, multiple objectives, multiple alternatives and multiple social interests and preferences. These models in essence refer to decision support systems that simultaneously accommodate quantitative and qualitative variables.
Scientific literature is rich with models ideal for the development of spatial decision support systems. It is up to the researchers in related fields to come together in developing integrative approaches to addressing poverty, inequitability and scarcity.

CONCLUSIONS and RECOMMENDATIONS

The developments in computer-based systems and their impact on society as a whole is still increasing and expanding. The emergence and seeming domination of the Internet has brought about a new economy bringing peoples and businesses closer than ever before. Computers are now an integral part of any organization and without which organizations have become obsolete or gobbled up by technology-based organizations.

Mapping technology has a practical place in natural resource management. Technologies developed elsewhere should be tested in other situations to take opportunity of such technology's capabilities. Once these are tested, the necessary adjusted, if any, can be implemented to ensure applicability to local situations and circumstances. Geomatics has allowed many organizations to better manage their activities as well as identify solutions to pressing problems in a more responsive way. While this technology has more or less empowered natural resource organizations, the underlying principles necessary for its integration is still ad hoc.

Following are the recommendations for a sustainable biodiversity conservation and management:

- Compile and prepare checklists of the organisms (including fauna, flora, and microorganisms) known to be indigenous to the study site and determine their conservation status, including those of specific habitats and areas towards the development of a biodiversity decision support system for Mt Makiling. Such a decision support system shall be used as the basis for:
  - identifying 'biodiversity hotspots', critical watersheds, and environmentally critical areas and determine their prioritization;
  - developing prescriptions for management strategies/options based on generated values/indices of biodiversity
  - modeling of impact resulting from landuse change including mitigation measures

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