AN ANALYSIS OF DRIVERS OF LAND USE CHANGE: THE CASE OF BAKUN, NORTHERN PHILIPPINES

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March 2011

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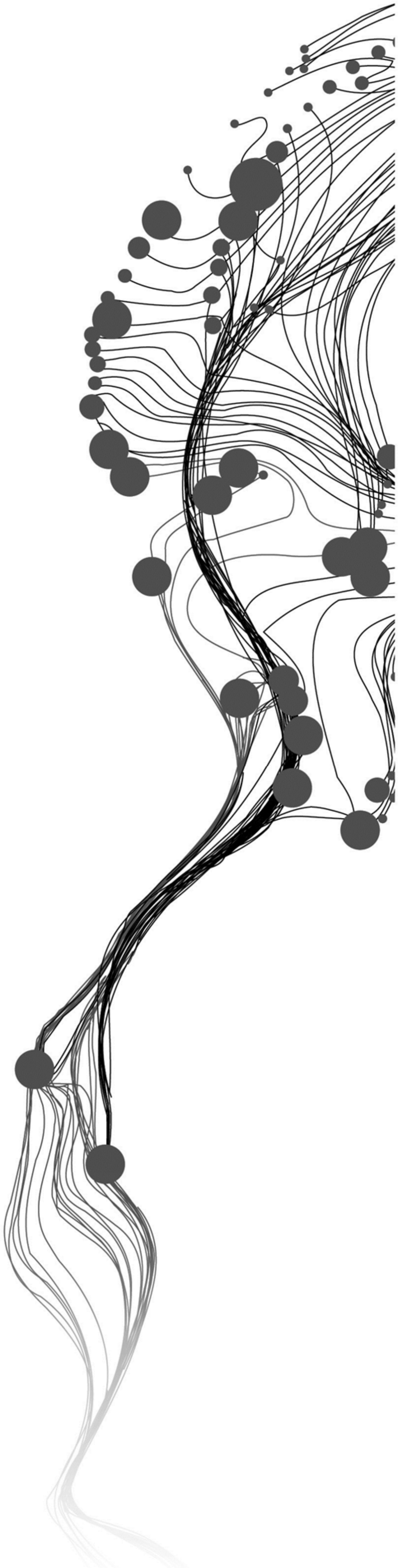

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Specialization: Governance and Spatial Information Management

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ABSTRACT

The need to provide food, water, timber, fiber and fuel to a global population that recently surpassed seven billion is driving worldwide alterations to forests, waterways, air quality, as well as farmlands. The increasing degradation of ecosystems and the diminishing quality and quantity of ecosystem services brought about by human activity are resulting to significant land use changes. Land use change is a complex, dynamic process that links together natural and human systems and is recognized as an important factor in the functioning of environmental and socio-economic systems at local, regional and global scales. There are direct and underlying causes of land use change and a considerable amount of work attempts to analyze which factors are the dominant driving forces of land use. This study aims to describe the developments in Bakun, an upland farming municipality in the northern Philippines, and to analyze the most influential drivers of change that affect its economic and spatial developments. The study reveals that the most important direct causes of land use change over the years are industrial timber extraction, agricultural expansion, the improvement and extension of roads, and conservation. Underpinning these direct causes differently are (1) demographic factors, namely a growing population, a transient farming population and the outmigration of locals for employment elsewhere; (2) economic factors, primarily market access, local government income from mini-hydro power generation, employment and off-farm livelihoods; (3) national policies implemented in the area over the years, and (4) cultural factors, primarily the recognition of customary rights to land and indigenous forest management practices. A land use/land cover change analysis provided proof of spatial transformations. This research concludes that policies exert the greatest influence in land use change.

Keywords: drivers of land use change, land use/land cover change analysis

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1. INTRODUCTION

1.1. Background

The need to provide food, water, timber, fiber and fuel to a global population that recently surpassed seven billion is driving worldwide alterations to forests, waterways, air quality, as well as farmlands. In 2005, the Millennium Ecosystem Assessment reported that one quarter of the earth's terrestrial surface is devoted to cultivated systems, i.e. at least thirty percent of the landscape is utilized for activities like cropping, shifting cultivation, confined livestock production, or freshwater aquaculture. Man's activities have permanently altered the structure and functioning of ecosystems to the extent that nearly two thirds of the services provided by nature for human well-being and economic development are found to be in decline worldwide (*Millennium Ecosystem Assessment Report, Ecosystems and Human Well-Being: Synthesis*, 2005). Note, further, that in the last 30 to 50 years, marine resources have totally disappeared or are now permanently degraded; and compared to the first half of the 20th century, the impounding of water in dams quadrupled and the withdrawal of water from rivers and lakes primarily for agriculture doubled. It is clear that any increase in the immediate supply of material goods will likely undermine, in the long term, many natural resources or ecosystem services (Foley et al., 2005).

The increasing degradation of ecosystems and the diminishing quality and quantity of ecosystem services brought about by human activity led to calls for change. In 1987, a call was made to sustainable development, defined as a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (*The Brundtland Report, Our Common Future* 1987). The world's attention was drawn to the urgency of pursuing economic development that could be sustained without depleting natural resources or harming the environment.

In 1992, a sustainable development blueprint was developed during the United Nations Conference on Environment and Development. Agenda 21 essentially provides guidance on how to pursue a development that is socially, economically and environmentally sustainable in the 21st century. Many national governments at that time made a commitment to promote it at all levels within their countries; and implicit was the need to protect and restore the vitality of endangered (and shared) ecosystems within their territories (Bressers & Rosenbaum, 2003). Yet, more than a decade later, the degradation of natural resources and ecosystems has not slowed. In 2005, a warning was issued on the risk of an ecological collapse in many regions of the world if the trend continues. Another urgent call was made to search for alternative options on how sustainable development can be pursued, and suggested that no less than a change in policies, institutions and practices can mitigate some of the negative consequences of mounting pressures on ecosystems (*Millennium Ecosystem Assessment Report, Ecosystems and Human Well-Being: Synthesis*, 2005). The task to be addressed is therefore two-fold – environmental conservation objectives and economic development goals.

Many solutions, including reforestation, agroforestry and social forestry programs and the establishment of protected areas were designed and implemented. Other remedies were imposed, such as environmental taxation and command-and-control regulations that generally restricted access and land use. These particular measures however were regarded as ineffective due to widespread non-compliance, weak governance, high transaction costs and lack of information on such aspects as enforcement and monitoring, and gave rise to other mechanisms, such as the negotiated agreements or covenants in the Dutch environmental policy (Bressers, 2004).

In developing countries, integrated conservation and development projects were widely implemented. These projects pursued conservation objectives and included rural development components, such as providing participants alternatives to environmentally-damaging activities and encouraging them to maintain or provide ecosystem services. Unfortunately, the scheme failed to change habits. Project participants accepted the alternative income sources as a complement and not a substitute to their existing environmentally-damaging activities; as such the pressure on resources had not eased (Blom, Sunderland, & Murdiyarso, 2010; Engel, Pagiola, & Wunder, 2008).

Participation in sustainable development thus requires a rethinking of how actors negotiate, organize and manage natural resources. Different groups of actors do not always share the same norms and values and there is frequently an unequal distribution of power among them. This often leads to tensions on resource use and management and could thus hinder sustainable development. (Bressers & Rosenbaum, 2003; Rist, Chidambaranathan, Escobar, Wiesmann, & Zimmermann, 2007). It is proposed that there be openness "to create new, or unfamiliar, modes of formal and informal relationship among the social levels involved" (Bressers & Rosenbaum, 2003); and to understand how the norms and values of sustainability can be concretized in specific situations to allow actors to communicate (Rist, et al., 2007).

1.2. Justification: The study of land use change

Policies on resource exploitation, forestry, agricultural productivity, ecosystem services, landscape functions, economic development and the like influence land use change. Land use change is a complex, dynamic process that links together natural and human systems; it is recognized as an important factor in the functioning of environmental and socio-economic systems at local, regional and global scales (Aspinall & Hill 2008; Koomen & Stillwell 2007). At the global scale, for example, the on-going land-use/land-cover change taking place probably represents the most important component of global change now and in the future. Human activity has already transformed close to half of the earth's ice-free surface and the changes are directly related to many environmental issues of global importance (Vitousek 1994).

There are direct and underlying causes of land use change and a considerable amount of work attempts to analyze which factors are the dominant driving forces of land use. A driver of change is defined as a natural or human-induced factor that directly or indirectly causes a change in the ecosystem. These include changes in climate, plant nutrient use, land conversion and diseases and invasive species. Direct drivers unmistakably influence ecosystem processes and operate in a more diffused way by altering one or more of the direct drivers; categorized as demographic, economic, socio-political, cultural and religious, and scientific and technical.

Land use change and the physical modification of rivers or water withdrawal from rivers is one of the direct drivers of ecosystems change (Millennium Assessment Report 2005). It has direct impacts on soil, water and the atmosphere and profound effects on biological diversity on land and on ecosystems downwind and downstream of affected areas (Vitousek 1994; Koomen & Stillwell 2007). Examples of land-use change with strong likely impacts on biodiversity, soil degradation and the earth's ability to support human needs are deforestation and subsequent transformations of agricultural lands in the tropics (Lambin *et al.* 2003). Further, land-use change is an important factor in the climate change cycle, and the relationship between the two is symbiotic where changes in land use affect climate and climatic change influences future land-uses (Berglund 2003; Jong & Lageras 2011).

Land use has thus been used in various ways to characterize the state of the natural environment. It is itself a measure, for example, to track the area of cultivable land of high conservation value. In other ways, it is considered as a substitute for some wider environmental pressure, such as the conversion of land to cultivation and the implications this might have on erosion or other similar processes. Further, it has been used as an indicator to gauge the effectiveness of a particular policy. Because of these, "land use is viewed as one of the core concepts used that can represent sustainable development issues and to measure progress towards this important goal" (Potschin 2009: S170).

The interest in the study of land use is thus increasing within and beyond academia. Topics explored are diverse, from the nature of land use and land cover, to their changes over space and time, and to investigating the social, economic, cultural, political, decision, environmental and ecological processes that produce these patterns and changes (Aspinall 2006). With the recognition that land use systems are illustrations of socio-ecological (or coupled natural and human) systems, their study requires the association and integration of natural science and social science approaches (Aspinall & Hill 2011); and as seen in numerous studies, such an integration of disciplines puts to good use the data capture, management, modelling, analysis, and visualization capabilities of Geographic Information Systems and remote sensing.

1.3. Research problem

In the Philippines, current land use and land cover are largely shaped by its policy history and objectives on resource use. For example, Philippine forest policies from the early 1900s until the mid-1970s were geared toward the industrialization of the forestry sector. This concentrated forest benefits to the privileged few, and worsened upland poverty and forest depletion (Pulhin, 1996). Industrial extraction since the post-WWII period and more unabated timber harvesting into the 1970s left only a 23% forest cover by 1987. A shift to protection, rehabilitation, and development of forestlands was introduced in the 1980s and log production gradually decreased through some degree of compliance with annual allowable cuts for each logging concession. In 1991, logging became officially prohibited in primary forests, in areas over 1000 meters in elevation and in areas with slopes of 50% or more (Guiang, 2001). Today, there are 1.39 million hectares of Philippine forests covered by various logging arrangements, such as Timber License Agreement, Integrated Forest Management Agreement, and Socialized Industrial Forest Management Agreement. At least 1,959 entities hold the rights to these agreements that comprise 22 percent of the country's remaining 6.43 million hectares of forest cover (FMB-DENR, 2008).

To accommodate a rapidly growing population, natural areas gave way to settlement areas; and to provide for food, fiber and other needs, agricultural production areas expanded. Coinciding with the rapid decline in forest cover, upland agriculture increased six-fold between 1960 and 1987. Forest frontier expansion to produce commodities like corn, tobacco, pineapple and temperate vegetables were influenced by agricultural policies on agricultural modernization.

Forest lands are home to upland communities who are dependent on forest resources. High rates of forest clearing in the uplands are driven partly by the efforts of low-income farmers not only to secure subsistence (Lasco & Pulhin 2000; Shively 2001) but also to produce agricultural commodities commercially. Further, roughly half of the country's population of 88 million lives in rural areas where poverty is most severe and most widespread. Close to 80% of the country's poor people live in rural areas and agriculture is the primary livelihood. The identified causes of rural poverty are a decline in the productivity and profitability of farming, smaller farm sizes and unsustainable practices that have led to deforestation and depleted fishing waters. Rural areas lag behind in economic growth and are characterized by underemployment, due in part to limited access of the poor to productive assets, business opportunities and limited off-farm livelihood options (International Fund for Agricultural Development 2009).

The period following the historic "people power" revolution in 1986 that toppled the dictatorship of President Marcos saw many changes in policy. After the Philippine Constitution was revised in 1987 which established the basic framework on protecting the individual and collective rights of citizens (Boquiren, 2004), two landmark laws were passed. The Local Government Code of 1991 decentralized governance by devolving some structures and processes to local government units (LGUs), namely provinces, municipalities and barangays. Among others, the Code passed on to the LGUs the role of developing plans and implementing programs to the local government units. It opened avenues for greater civil society participation, such as representation in local councils and sectoral committees; handed down the task of basic service provision, specifically in education, health and social welfare and the task of implementing local development projects; allocated for each LGU a share in the national income; and gave LGUs taxing and revenue-raising powers. In 1997, Republic Act 8371 or the Indigenous Peoples' Rights Act was signed into law. It recognises and promotes the rights of indigenous peoples to ancestral domains and lands; the right to self-governance; economic and social rights; and cultural integrity, including indigenous culture, traditions and institutions. Embedded in both laws is the pursuit of sustainable development.

Contributing to building knowledge on land use for scientific and advocacy purposes are the primary motivations of this present study. Land changes occur differently at different rates and through a different mix of drivers; thus possibly with a different set of future management options. Through a case study, it will contribute to understanding the most influential drivers of land use change and their effects on economic development and spatial transformations. "The real business of case study is particularization, not generalization. (A particular case is taken) and come to be known well, not primarily as to how it is different from others but what it is; what it does. There is emphasis on uniqueness, and that implies knowledge of others that the case is different from, but the first emphasis is on understanding the case itself" (Stake 1995: 8).

The case study is a municipality and an upland agricultural community in northern Philippines. It is located within the Cordillera, a region that is home to thirteen major watersheds touted to be playing a key role in maintaining ecological balance in northern Philippines. The government's economic development objective in this region since the post-war period was executed through mining, logging and commercial vegetable production, which resulted in further deforestation (Colongon *et al.* 2005). About 80% of total area is classified as forest land that is home to some of the country's most unique flora and fauna. Of the 1.6 million hectares of proclaimed forest and watersheds, it has only 668,801 hectares of forest cover in 2003; losing an average of 500 hectares annually in the last 10 years. These forest incursions are causing soil degradation and soil erosion resulting to massive forest denudation, exacerbated by a mountainous and high elevation terrain (NEDA-CAR 2011); in the end threatening after all the ecological balance in the region.

Itself a watershed, Bakun has gone through many dramatic changes notably since the post-World War II period. It is a natural resource-rich community and home to two indigenous groups. The forest resources in the area were harvested commercially for half a century and its hydrologic resources are currently in use for electric generation. National policies currently in place and customary law influence its socioeconomic and spatial transformations.

1.4. Research objectives

1.4.1. General objective

To describe the developments in the municipality of Bakun in northern Philippines and to analyze the most influential drivers of change that affect economic and spatial developments.

1.4.2. Specific objectives

1. To analyse the drivers of land use change in Bakun, northern Philippines.
2. To undertake a land use/land cover change analysis in the study area.

1.5. Research questions

1. What are the important events in the study area?
2. What are the causes of land use change in the area, and what are the most influential of these causes
3. What are the land use/land cover classes in the area?
4. In what way have land uses changed as a result of changes in land use policy in the area?

1.6. Research design

As the diagram shows, the study essentially followed six steps.

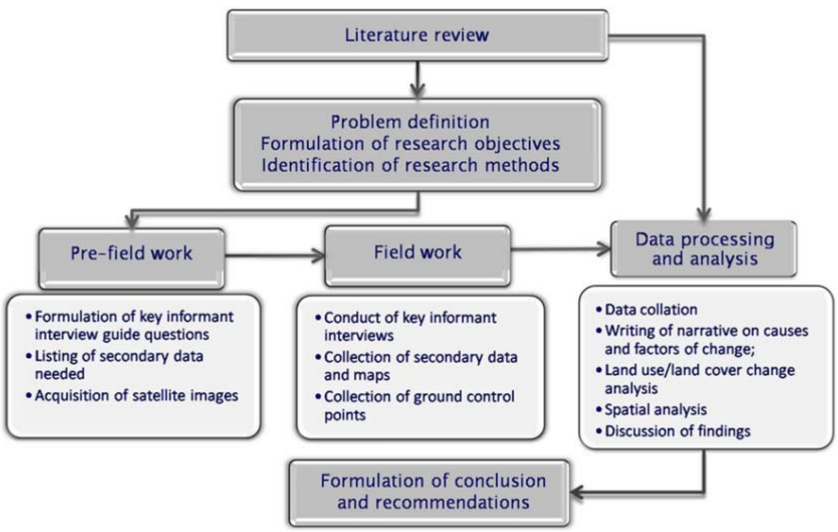

Figure 1.1: Research design

1.7. Thesis structure

This chapter provides the background of the study; the justification for pursuing the topic described, a description of the research problem to be studied, and the research objectives and questions to be addressed. The background describes the current global state of natural resources and ecosystems, the advocacy on sustainable development, and responses and possible future actions in the pursuit of a sustainable future. The justification is framed to reflect the need to study land use change and its causes.

Chapter 2 presents a review of concepts on land use and with focus on drivers of land use change. Chapter 3 presents the profile of the study area, materials and methods used in the study. Chapter 4 is a narrative on the development of the study area, with descriptions of the drivers and underlying factors that influence land use change. Chapter 5 contains the results of the land use/land cover change analysis, as well as the results of spatial analysis on class conversions and effect of roads on land use change. Chapter 6 contains a discussion on the drivers of change, focusing towards the end on the most influential factors of change and to draw insights on how these influential factors affect socioeconomic and spatial developments in the study area. Chapter 7 contains the conclusion and recommendations of the study.

2. REVIEW OF CONCEPTS ON LAND USE CHANGE, GOVERNANCE AND REMOTE SENSING

2.1. Introduction

Patterns and changes over space and time are produced by the interplay of social, economic, cultural, political, environmental and ecological processes. To comprehend land use, its role and importance, land use change, land management and policy, as well as the importance of land use for sustainability, the application of various theories, methodologies and technologies is required (Aspinall 2008).

Different disciplines have indeed studied land change; but the different paradigms and theories applied are not easily incorporated and research results are difficult to combine into an integrated understanding of land use/land cover change. Note for example, that geographical approaches usually aim to identify the location of land use/land cover change in a spatially explicit way, while socio-economic studies seek to understand the processes of land use/land cover change and often lack spatial context and interactions (Overmars & Verburg 2004). Lambin, *et al.* (2003) suggest three elements for an integrated theory of land change: (1) to investigate the behaviour of people and society and their reciprocal interaction with land use, (2) to be multilevel with respect to both people and the environment, and (3) to be multi-temporal so as to include both the current and past contexts in which land, people and the environment interact. The purpose of this chapter is to provide an overview of concepts related to the study of land use/land cover, with focus on the social drivers of change and consequences of land use change.

2.2. Land-cover and land-use change defined

Land cover refers to the physical characteristics of the earth's surface, mostly described by the dominant, observable vegetation or structures. These features could be vegetation cover, water bodies and rock outcrops, to name a few. To say that there is land cover change is when there is an alteration of the physical or biotic nature of a site, for example the conversion of forest to grassland (P. Vitousek, 1994). Meanwhile, land use refers to man's use of the land and its cover or is defined by the purposes for which humans exploit the land cover (FAO, 1995; Kerr & Cihlar, 2005; Lambin, Geist, & Lepers, 2003). Land use change then involves the alteration of the way humans use land, such as in the conversion of low-input agricultural land to high-input uses or vice versa (Meyer & Turner, 1992). This process involves both the change to a different function and shifts in the type or intensity of human exploitation within a function, making it probably the most important factor influencing the conservation of natural environments (P. M. Vitousek, Mooney, Lubchenco, & Melillo, 1997).

While, land cover and land use are conceptually different, with de Bie (2002) pointing out that for "any exercise involving change detection, causes (e.g. change in land use) and effects (e.g. change in cover) are kept apart", the term land use will be used in this study to refer to both land cover and land use for convenience, as did Koomen and Stillwell (2007), inasmuch as the focus was in finding out broadly the changes that have occurred over time in the study area.

2.3. Land use change as focus

Different disciplines have indeed studied land change; but the different paradigms and theories applied are not easily incorporated and research results are difficult to combine into an integrated understanding of land use/land cover change. Note for example, that geographical approaches usually aim to identify the location of land use/land cover change in a spatially explicit way, while socio-economic studies seek to understand the processes of land use/land cover change and often lack spatial context and interactions (Overmars & Verburg, 2005). Lambin, *et al.* (2003) suggest three elements for an integrated theory of land change: (1) to investigate the behaviour of people and society and their reciprocal interaction with land use, (2) to be multilevel with respect to both people and the environment, and (3) to be multi-temporal so as to include both the current and past contexts in which land, people and the environment interact. The purpose of this chapter is to provide an overview of concepts related to the study of land use/land cover, with focus on the social drivers of change and consequences of land use change.

In general, landscapes transform as a result of a change in land use activities. As illustrated by Foley *et al.* (2005) societies appear to follow a sequence of different land-use regimes: from pre-settlement natural vegetation to frontier clearing, then to subsistence agriculture and small-scale farming towards intensive agriculture, urbanization and creation of protected and recreational lands. This is a general trend and landscapes transform differently and not always in a linear fashion. Furthermore, transitions are influenced by unique histories, social and economic conditions, as well as ecological contexts.

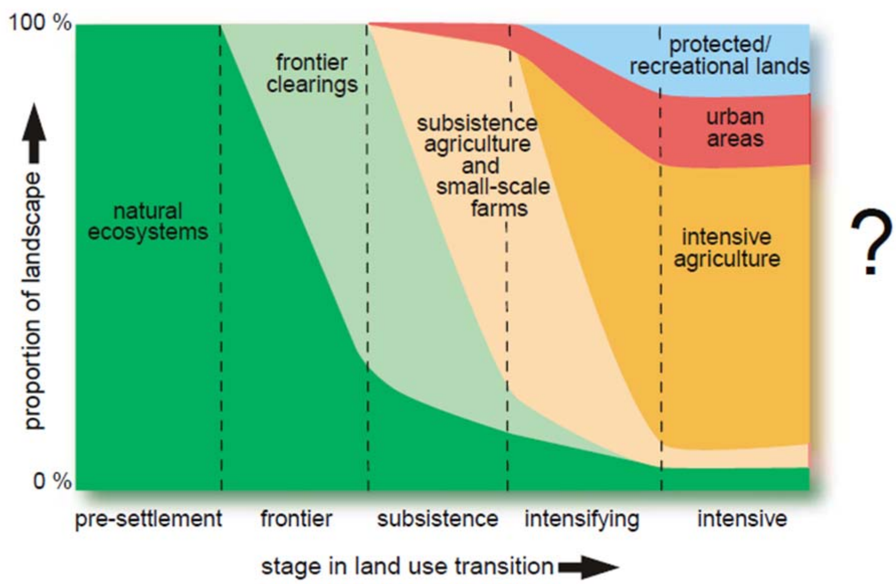

Figure 2.1: Land Use Transitions (Source: Foley *et al.* 2004: 571)

2.4. Drivers of land use change

A considerable amount of work on land use change attempt to analyze which factors are the dominant driving forces of land use. A driver of change is defined as a natural or human-induced factor that directly or indirectly causes a change in the ecosystem. These include changes in climate, plant nutrient use, land conversion and diseases and invasive species. Direct drivers unmistakably influence ecosystem processes and operate in a more diffused way by altering one or more of the direct drivers. Global driving forces are categorized as demographic, economic, socio-political, cultural and religious, scientific and technological, and biological and physical (*Millennium Ecosystem Assessment Report, Ecosystems and Human Well-Being: Synthesis*, 2005). As to what cause change in land use/land cover, the International Geosphere & Biosphere Program (IGBP) and the International Human Dimensions Program (IHDP) which are jointly undertaking the International Land Use/Cover Change Program propose natural environments, land use management, and socio-economic factors as the three main driving forces of land use/cover change. In particular, natural environments include air temperature, precipitation, and topography; land use management refers to land development policies, such as zoning and smart growth; and socio-

economic factors include population information, education levels, social trends, economy, and technology development (Yu, Zang, Wu, & Na, 2010).
Izquierdo and Grau (2009) identify two broad categories of land use change patterns: (1) expansion of the agriculture frontier, considered to be a major driver of deforestation and destruction of natural habitats, particularly in tropical and subtropical lowlands where productive soils and a growing global demand for food and other agriculture products provide incentives for transforming areas into agriculture; and 2) ecosystems recovery associated with a decrease in intensification of land use in marginal agriculture lands that is associated to industrialization and population urbanization.

Geist and Lambin (2002) investigated 152 local-scale case studies to acquire an understanding of the proximate causes and underlying drivers of tropical deforestation. Proximate causes are defined as human activities or immediate actions at the local level (individual farms, households or communities. On the other hand, underlying driving forces are fundamental social processes, such as human population dynamics or agricultural policies that strengthen the proximate causes and either operate at the local level or have an indirect impact from the national or global level. "They are formed by a complex of social, political, economic, demographic, technological, cultural, and biophysical variables that constitute initial conditions in the human-environment relations and are structural (or systemic) in nature" (Geist & Lambin, 2002; Lambin, et al., 2003). Proximate causes were grouped into four, namely agricultural expansion, wood extraction, infrastructure extension and other factors; and underlying driving forces were grouped into five clusters, namely demographic, economic, technological, policy and institutional, and cultural factors.

2.4.1. Agricultural expansion

Geist and Lambin (2002) identify agricultural expansion as one of three proximate causes of forest loss Findings from 152 cases suggest that the proximate causes and drivers of land cover change cannot be reduced to a single variable or to even a few variables. They found that mainly three- and four-factor terms of underlying causation were related to two- and three-factor terms of proximate causation. In particular, agricultural expansion, in combination with other causes or factors, contributes to most of the variable combinations.

Tropical forest and shrubland ecosystems are natural ecosystems that provide locally and globally important services including storing of much of Earth's biomass carbon, serving as habitats for endangered plants and animals, preserving major elements of the global hydrological cycle, and protecting massive watersheds. Expansion of the global agricultural land base inevitably means clearing these ecosystems. Indeed, proof of this comes from a statistical survey carried out by the Food and Agriculture Organization of the United Nations on 117 sampling units across the tropics: 47 in Africa, 30 in Asia, and 40 in Latin America and covering the period 1980-1990. Over 55% of new agricultural land came at the expense of intact forests, woodlands, and savannas and another 28% came from disturbed forests, such as those brought by shifting cultivation, logging, fuel wood collection, or other forms of gradual degradation. "This study underscores the potential consequences of unabated agricultural expansion for forest conservation and carbon emissions" (Gibbs et al., 2010).

The expected increase in worldwide demand for agricultural products will increase by ~50% by 2050 and meeting this demand might fall on tropical countries. The evidence for this is changing trends between developed and developing countries. In the former, the agricultural land area, including pastures and permanent croplands, decreased by more than 412 million ha (34%) between 1995 and 2007. On the contrary, developing countries saw increases of nearly 400 million ha (17.1%). If such agricultural expansion trends documented here for 1980–2000 persist, major clearing of intact and disturbed forests are expected to continue and increase across the tropics. A careful consideration for the future is in balancing "tradeoffs between the value of commodities obtained from expanding agricultural area and the services provided by intact ecosystems" (Gibbs, et al., 2010).

Other countries can report agricultural expansion from forests farther back in time. In peninsular Malaysia, for example, the development of cash crops has changed the country from one dominated by natural landscapes to one dominated by agricultural landscapes; and from the mid-90s, by urban areas, all in the course of a century. Landscape fragmentation and heterogeneity came about in three stages and follows the relative importance of products, i.e. rubber from the 1900 to the 1950s; palm oil from the 1960s to 1970s; a process, i.e. urbanization from the 1980s to the 1990s. The growth of urban centers is consistent with the establishment of various development policies, from land development for agriculture between the mid-1950s and the 1970s to an emphasis on manufacturing from the 1980s onward. Abdullah and Hezri (2008) predict that the environmental consequences of this change can result to loss of biodiversity, geohazard incidences, and the spread of vector-borne diseases.

Meanwhile, not too long ago, in 2001 to 2004, intensive mechanized agriculture in the Brazilian Amazon grew by more than 3.6 million hectares. It has not been quantified whether such an expansion was a result of intensified use of land previously cleared for cattle ranching or new forest clearing. Carried out in Mato Grosso, the Brazilian state with the highest deforestation rate and soybean production since 2001, deforestation maps, field surveys, and satellite-based information on vegetation were used to characterize the transformation of clearings of cropland, cattle pasture, or regrowing forest of over 25 hectares. One of the relevant results detected was the direct conversion of forest to cropland of more than 540,000 hectares from 2001 to 2004. The growing importance of larger and faster conversion of forest to cropland defines a new paradigm of forest loss in Amazonia and refutes the claim that agricultural intensification does not lead to new deforestation (see section on intensification). Indeed, recent studies confirm that large-scale agro-industrial expansion is the dominant driver of deforestation in this decade, showing a proportional fall in forest cover as commodity markets boom. Meanwhile, destruction of Amazonian rainforests for soy production and Southeast Asia peat swamp forests for oil palm production have been attributed to rising commodity prices. Drivers of cropland expansion may impact forests directly through local or regional demand or indirectly through more globalized demand that may occur via market-mediated effects (Gibbs, et al., 2010).

In the Philippines, agricultural expansion is contributory to further degradation of forests. The area devoted to upland agriculture increased six-fold between 1960 and 1987 (Verburg & Veldkamp, 2004) and generally matched the rapid decline in forest cover. The main reasons for this enormous expansion in upland agriculture are population growth, inadequate labor absorption and agricultural price policies. Also, high rates of forest clearing in the uplands are driven to a certain extent by low-income farmers to secure areas for subsistence production (Shively & Martinez, 2001). In Jinsha River in China, population expansion, food self-sufficiency and better market access drive cropland expansion (Yin, Xiang, Xu, & Deng, 2010).

2.4.2. Infrastructure development

It has long been asserted that an adequate supply of infrastructure services is an essential element to achieve productivity and growth (*World Development Report (Infrastructure Development)*, 1994). The significant role it plays in national or regional development has long been emphasized because in the first place, it improves the welfare of people through the improved direct delivery of education, health care and recreation. In the second place, the provision of roads, airports, utilities, bridges, etc. leads to improved productivity of producer capital, such as machinery, equipment, livestock, and others; and of consumer capital, like housing and residential structures. Infrastructure creation is therefore expected to create an extensive modification in the relative prices both of factors of production and final products and with these, a higher level of income and employment (T. R. Lakshmanan, 1989).

Inadequate transport infrastructure thus hampers socio-economic development. This is especially true in developing countries where "network accessibility is low, roads connecting local networks are often missing or in poor condition, vehicle load capacity is low, and there are often severe traffic bottlenecks" (Olsson, 2009). Given these, transportation costs remain a substantial part of production costs. It becomes more significant when transporting highly perishable goods, such as fish. These conditions likewise make production inefficient and expensive, engage more physical and human resources, and make competition low. As a result, the local markets have a limited catchment area and individual local markets are unlikely to merge into larger networks (Olsson, 2009).

2.4.2.1. Accessibility as a driver of land use change

One of the drivers of land-use and land-cover change is accessibility (Verburg, Overmars, Huigen, de Groot, & Veldkamp, 2006); (Geist & Lambin, 2002). It is defined as the ease with which goods can reach other places, measured in terms of time, cost, seasonality, and transport services provided (Olsson, 2009). Transport improvements open up new land for economic activities; and with lower costs and increased accessibility come market expansion and integration (T. Lakshmanan & Chatterjee, 2005)

The extent and the location of land-use conversions are influenced to a large extent by the ability of people to reach desired locations, such as a market or a forest. Previous analytical and empirical studies on land-use and land-cover change which incorporate accessibility focused on deforestation; concluding that improved access to forests accelerates deforestation. There were also studies that used remote sensing and GIS techniques to relate the location of roads or other indicators of access to deforestation patterns (Mertens & Lambin, 1997; Nepstad et al., 2001).

2.4.3. Commercial logging

One of the direct drivers of land use change as uncovered from 152 local-scale case studies (Lambin et al., 2001) is timber extraction. From the 55 Asian case studies, 82% involved some form of agriculture-wood connection, a result that presumably reflects experiences of countries with a wood industry.

Experiences across regions vary. The Latin American experience, as exemplified in the Amazon experience, begins with a phase of government-sanctioned extraction and harvesting of timber plus initial colonization; followed by the establishment of colonists that have access to capital and who undertake land-based enterprises like cattle raising. Rules on land ownership are redefined and those with more capital increase their land holdings while those with less expand the agricultural frontier further. The conversion of wide tracts of land for pasture to support lucrative cattle raising increases land prices and further consolidates land.

Central African nations generate foreign revenue through intensive use of natural resources, including timber. Regulations are usually weak, characterized by inadequate law enforcement and corruption. Uncontrolled logging continues and the related environmental impacts follow. Migrants soon follow logging roads and clear more land for food and farming. Socio-economic factors, such as the devaluation of the national currency, changes in market prices of agricultural commodities, contract farming and social conflicts define the amount of land that cultivators clear and the length of their fallows.

In Southeast Asia, countries seek to increase state revenues and achieve socio-political stability in frontiers by launching large forest development projects, either through timber extraction initiatives or transmigration to settlement schemes and plantations. Similar to the experience in Central Africa, there is failure to enforce timber concession regulations by authorities, worsening the damages in areas logged and encouraging further spontaneous settlement. Likewise, large-scale plantation and intensive agricultural projects increase migrant involvement with commercial cultivation, often at the expense of indigenous people living near the forest frontier, where land conflicts follow (Lambin, et al., 2001).

2.4.4. Policy

The direct influence of policies on resource exploitation, forestry, agricultural productivity, ecosystem services, landscape functions, economic development and the like; their unintended outcomes in land use change, as well as necessary policy responses to land use change are investigated. Environmental sustainability is problematized in which the role of policy is investigated or possibly directed to address environmental issues (Veldkamp & Lambin, 2001). Considering the speed with which land is transformed and worrying over issues of unsustainable resource use, the need for decision-making and policy actions across multiple geographic scales and multiple ecological dimensions have to be considered. This is the required action since land use occurs in local places, with real-world social and economic benefits, but potentially cause ecological degradation along local, regional and global scales. It is thus incumbent on society to develop strategies that balance efficiency, i.e. reduce the negative environmental impacts of land use across multiple services and scales, and equity, i.e. maintain and provide social and economic benefits (Foley, et al., 2005).

The question on whether environmental policies harm the livelihoods of the poor living in and around environmentally sensitive areas has been raised, and many studies have proven this to be true. There are well-intentioned measures to conserve the environment but the costs fall on the poor who are least able to bear them; and that those most vulnerable will ignore or deliberately disregard such measures to secure their livelihoods. It then raises issues on equity but also challenges the effectiveness of the policies. Many natural resources protection policies such as restrictions on land and water use, limits on extraction and harvesting of resources, measures on environmental waste disposal, to a certain extent will require additional costs on some economic activities and social groups. How substantial these costs are depends to a certain extent on how important the resource in question is to the livelihoods of affected people, such as forest and coastal area dwellers (Wiggins, Marfo, & Anchirinah, 2004).

There are policies for forestry, and for development in general, that encourage large-scale conversion of forests. Infrastructure development, such as road and railway building, remove the natural isolation of forests; tax concessions fund timber extraction or plantations; resettlement schemes allow people to settle in the forest as farmers; and many land titling regulations encourage the clearing of tree stands as a condition for getting a formal title to the land. No matter the intent, policies for economic growth within forested areas encourage the removal of forest to some extent; also hastening clearing and degradation. In developing countries where these are occurring, government agencies address the rate of forest loss by establishing protected areas or regulating logging. These measures, however, have largely been ineffective. The sheer size of forests simply does not allow adequate monitoring and forest users can easily ignore the rules (Wiggins, et al., 2004).

Learning from past failures brought a reconsideration on the part of governments to involve the people in forest decision-making and implementation (Bass et al., 1997; Poffenburger, 1996). It is claimed that these new regimes will incorporate and reflect the diversity of local circumstances, offer local people to exercise rights to the resources and have a greater say in decisions over their use; in the end affording them the incentive to conserve the forests (Wiggins, et al., 2004).

In investigating the causes of land use change in the Jinsha River, for example, the main purpose was to be able to recommend necessary policy actions for more sustainable land use and environmental protection. Similarly, concerned with the substantial changes in land use over the past several decades in the Upper Yangtze River as a result of continuing population growth and rapid economic development, China is addressing simultaneously the demands for food and raw materials; urban expansion, and environmental conservation (Yin, et al., 2010). Meanwhile, Willemen, Hein & Verburg (2010) focused on rural landscapes and their various functions.

Landscapes not only produce agricultural commodities, but also a multitude of services that benefit people, including food and timber production, fresh water supply, and recreational opportunities. The potential to provide such services depends on the spatial configuration and components of the landscape and by changing landscape properties, human activities can directly or indirectly affect the supply of landscape services. Spatial policies are thus designed to influence the landscape in such a way that the provision of one or more landscape services is improved, even as the design and implementation of regional spatial policies also require the need to address trade-offs. Landscapes are spatially diverse and the unequal distribution of landscape services over an area is inevitable. As such, an evaluation of policy effects demands being spatially explicit since policies are likely to have a location-specific effect on the provision of landscape services (Willemen, Hein & Verburg 2010).

2.4.5. Other underlying causes of land use change

The analysis of cases on tropical deforestation revealed some identifiable regional patterns of causal factor (quantified by determining the most proximate and underlying factors in each case) synergies, of which the most prominent are economic factors, institutions, national policies and remote influences (at the underlying level) driving agricultural expansion, wood extraction and infrastructure extension (at the proximate level).

At the underlying level, 88% of the cases were driven by multifactor terms of causation and that economic factors were most prevalent as seen to be present in 81% of the case studies. This compares to 63% on policy and institutional factors, 59% technological factors, 56% socio-political or cultural factors and 51% demographic influences (Geist & Lambin, 2002). Meanwhile, in a study of causes of land use/land cover change in the Jinsha River in China, industrial development was viewed to contribute significantly to the increase of forestland and the decrease of other land uses. Also, stable tenure has a positive effect on forest protection, and that past land use decisions were less significantly influenced by distorted market signals (Yin, et al., 2010).

2.4.6. Governance and sustainable development

Sustainable development is now widely propagated and has become an important strategic concept no matter at what level public policy is discussed (Bressers & Rosenbaum, 2003). It has been proposed by Bressers and Kuks (2003) that the pursuit of sustainable development demands societal change; and a "recognition that government alone no longer determines the development of sectors in society; (but) are shaped through the interaction of many actors" and within such a network of actors, the government can position itself as the dominant actor. This is then a shift from 'government' to 'governance', described by the United Nations as the "exercise of political, economic, and administrative authority to manage a nation's affairs, including complex sets of institutions, systems and processes that engage the state, civil society and the private sector in a democratic and transparent way" (p.3) (Bressers & Rosenbaum, 2003). Further, Bressers and Kuks (2003) identified five elements of governance, essentially consisting of five questions: Where? Who? What? How? and With what?, indicating that governance systems are characteristically multi-level, multi-actor, multifaceted, multi-instrumental and multi-resource-based. Also, Bressers and Rosenbaum believe that in the pursuit of sustainable development, governance "entails a structure of shared responsibilities among social actors and various instruments to facilitate collaboration" (p. 4). Further, that three aspects of sustainable development that require integration are sectors and aspects (to embrace the three dimensions of sustainable development namely economic, ecological and social equity), scales and levels (coordination among social actors), and assumption of the long time horizon of problems, the required policy responses, creating uncertainties, and the necessity of continuous learning (Bressers & Rosenbaum, 2003).

2.5. Remote sensing and GIS in land use/land cover

Land use is determined by the interaction in space and time of biophysical factors, such as soil, climate, topography, etc. and human factors like population, technology, economic conditions, and others (Veldkamp & Fresco, 1996) and such a complexity of land-use systems demands multidisciplinary analyses (Aspinall, 2008; Foley, et al., 2005; Geist & Lambin, 2002; *Millennium Ecosystem Assessment Report, Ecosystems and Human Well-Being: Synthesis*, 2005).

Efforts to understand this interaction have led to innovations in integrating geo-information and socio-economic and other qualitative data using GIS and remote sensing technologies. From a geographical standpoint, land use/land cover change studies have in the beginning mostly been done at national and sub-national levels, utilizing data from census, topographic maps or satellite images to identify causes of land use change and which are used to explain the location of changes. But while these studies are explicit spatially, i.e. clear at the pixel level, and are effective means to help explain land use patterns, they lack explicitness in processes and human behavior. This, on the other hand, is the strength of the social sciences, i.e. the conduct of micro-level studies that aim to understand people-environment interactions (Overmars & Verburg, 2005; Turner et al., 2003). Methodologically, researchers endeavor to connect spatial pattern to land use process by integrating GIS, socio-economic, and remote sensing techniques with landscape ecological approaches (Nagendra, Munroe, & Southworth, 2004) especially as remote sensing now provides resources, such as images and aerial photos, for the study of land use and land cover change.

Change detection, defined as the process of identifying differences in the state of an object or a phenomenon by observing it at different periods (Singh, 1989) has been utilized in many land use studies, and monitoring of change, whether on deforestation or reforestation, is viewed as among the most important contributions of remote sensing technology to the study of global ecological and environmental change. (Brandt & Townsend, 2006)) carried out an assessment of regional land cover patterns in the Southeastern Bolivian Andes. Using supervised classification on Landsat imagery, the current landscape patterns in the study area were characterized and land cover change was quantified from 1985 to 2003. The analysis showed that extensive deforestation, desertification, and agricultural expansion at a regional scale occurred in the last 20 years. (Chowdhury, 2006) reviewed spatial methodologies aimed at identifying driving forces of land use change, then applied one of these methodologies to understand deforestation in Mexico. (Kamusoko & Aniya, 2006) carried out a hybrid supervised/ unsupervised classification approach coupled with GIS analysis to generate land use/cover maps towards finding explanations to landscape fragmentation in the Bindura District in Zimbabwe. Findings pointed to anthropogenic activities driven by agricultural expansion were the main causes of landscape fragmentation.

Zhang, et al. (2009) used remote sensing and GIS to identify the ecological problems in two national nature reserves in China that are under heavy human influence. A classification of Landsat images produced relatively accurate landscape change maps and where quantitative information on the magnitude of change and the changes from one class to another were readily derived. Out of these, the characteristics of landscape change were better explained. Ultimately, accurate change detection of earth surface features provides the foundation for greater understanding of the relationships and interactions between human systems and natural phenomena. The FAO statistical survey on 117 sampling units went beyond identifying locations of land-cover conversions. It also tracked land parcel transitions from one land-cover class to another. This method involved manual interpretation of the historical and recent images at the same time, thereby reducing errors associated with change detection. It also offers major advantages over single-period analysis or compilations of different sources of imagery (Gibbs, et al., 2010).

2.6. Summary

The study of land use demands the investigation of patterns and changes over space and time that are produced by the interplay of social, economic, cultural, political, environmental and ecological processes. Its role and importance, land use change, land management and policy, as well as the importance of land use for sustainability require the application of various theories, methodologies and technologies. The suggested elements for an integrated theory of land change are the investigation of the behaviour of people and society and their reciprocal interaction with land use; being multilevel with respect to both people and the environment; and being multi-temporal in order to include the current and past contexts in which land, people and the environment interact. Land cover refers to the physical characteristics of the earth's surface while land use refers to how man uses the land and its cover. While conceptually different, land use and land cover will be used in this thesis synonymously, at least in as far as referring to the land use maps produced from the remotely sensed data.

Land use/land cover change is brought about by natural or human-induced factors directly or indirectly. The natural environment, land use management and socio-economic factors are the three main driving forces of land use/cover change. In particular, natural environments include air temperature, precipitation, and topography; land use management refers to land development policies, such as zoning and smart growth; and socio-economic factors include population information, social trends, economy, and technology development. Proximate or direct causes identified are agricultural expansion, wood extraction and infrastructure extension; while underlying driving forces include demographic, economic, technological, policy and institutional, and cultural factors.

Policy in particular greatly influences resource exploitation, forestry, agricultural productivity, ecosystem services, landscape functions, economic development and the like. In many cases, policy measures have unintended outcomes to land use change.

Meanwhile, the study of land use change is aided by an ever expanding range of increasingly accessible satellite data. Innovations that integrate geo-information and socio-economic and other qualitative data using GIS and remote sensing technologies help to understand and explain the complex interactions of biophysical factors and human factors in space and time. Also, change detection or monitoring of land use and land cover change can be done by comparing two or more co-registered maps integrated into a GIS database and quantifying values. In analyzing results, it is important to keep in mind other features and factors, like scale, sampling methods, classification method and classification accuracy.

3. STUDY AREA AND METHODOLOGY

3.1. The Municipality of Bakun

The municipality of Bakun, in the province of Benguet in northern Luzon, Philippines was chosen for this study. It is within the latitudes 16°42' and 16°53'N and longitudes 120°33' and 120°48'E. It belongs to the Central Cordillera Forest Reserve and is relatively close to the lowland area; sharing its western flank with the municipalities of Alilem and Sugpon and its north with the municipality of Cervantes, all belonging to the province of Ilocos Sur. On its east is Mankayan and on the south are Buguias and Kibungan, municipalities of Benguet.

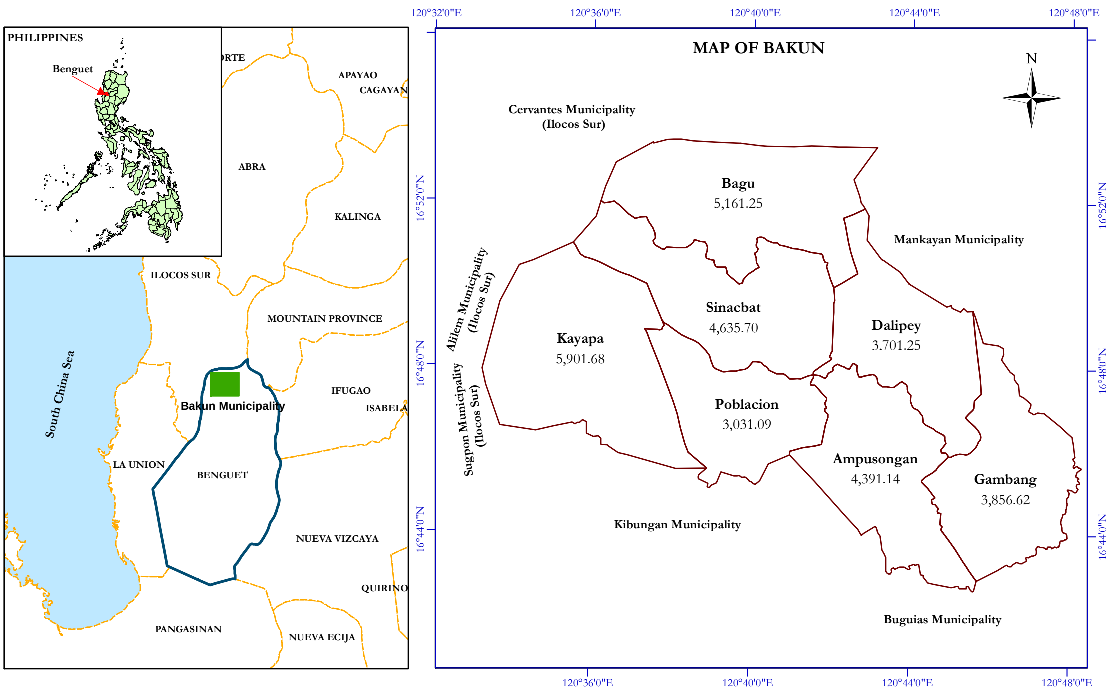

Figure 3.1: Location of Study Area

The municipality can be reached by land transportation from Baguio City through the Baguio-Bontoc Road. Baguio City is the so-called gateway city to the northern provinces of the CAR. Along with its very close neighbor La Trinidad which is also the capital town of Benguet, it is the center of large-scale vegetable trading and the market for various services and goods for inland municipalities. The Baguio-Bontoc Road or the Halsema Mountain Trail, so named after the American engineer who designed and oversaw its construction, is the main artery that links the northern municipalities to Baguio City. A secondary provincial road in Sinipsip, a settlement of Bakun along the national road, separates from the national highway and goes westward to reach six of the seven villages of Bakun. Meanwhile, entry to the seventh village called Kayapa is from Baguio City through Naguilian Road, another national highway towards the lowlands through the municipality of Alilem. The total municipal land area is 30,678.74 hectares, distributed to seven villages or barangays. The barangay is the basic political unit, the term to be used here interchangeably with village. Smaller settlements or zones within barangays or villages are called *sitios*.

3.2. Biophysical characteristics

The area is itself a watershed and supports four river networks. Gambang River in the south heads towards the northeast and merges with the bigger Abra River. Bakun River is the biggest of the four networks and the main system tapped for mini-hydro power production. It drains in the northwest along with Bagu River. Kayapa River in the west, on the other hand drains in the west to merge with another big system, the Amburayan River. Bakun has a rugged, mountainous terrain. Only about 15% of the watershed is relatively flat with 18 degrees slope and less. Seventeen% is moderately steep, (19 – 25 degrees), 54% is steep (26 – 45 degrees), and 13% is very steep with slopes over 45 to 85%. The area has a wide elevation range, from 120 meters above sea level in the west to 2,625 masl in the southern village of Gambang. About 70% of the total area has an altitude equal to or more than 1,000 masl. These characteristics allow lowland vegetation to thrive in the west and montane and pine in the rest of the watershed, with the former predominating.

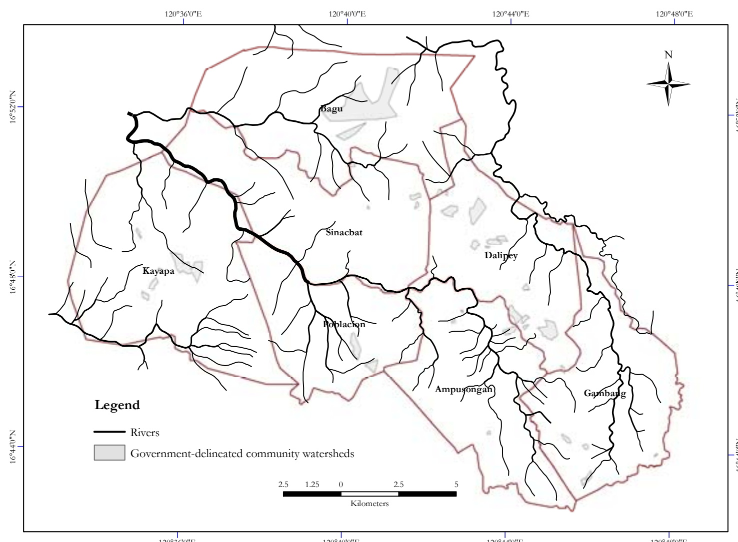

Figure 3.2: River Systems and Community Watersheds in Bakun

The municipality falls under Philippine Climatic Type I which is characterized by two pronounced seasons. The wet season occurs from April to October and the dry season from November to March. Rainfall is highest in August and lowest in January. Data from 1981 to 2003 showed that the wet season rainfall trend is stable with a slight increase in 2001 while the dry season rainfall was decreasing (Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA). Meanwhile, annual temperature ranges from 8 to 28°C; the coldest month is February and its pleasant summer weather peaks in April.

Prior to industrial logging in the area, Bakun had dense forests of montane and pine vegetation, characteristic of a temperate region, which is prevalent in the Cordillera Central where Bakun belongs. As reported by the municipal environment office in 2007, there are still areas of undisturbed highland vegetation covering the hills and mountains, with pine forests dominating in the higher elevations and lowland vegetation along the Ilocos border (*Bakun Integrated Watershed Development and Management Plan (2007-2017)*, 2007). Current land use/land cover classes are agriculture which includes vegetable gardens, swidden farms, paddy fields, home gardens and orchards; forest consisting of pine, montane and low elevation vegetation; pasture; and residential and institutional land.

3.3. Demographic characteristics

In the 2007 Census of Population and Households, the municipality's population was 12,137, lower by 0.6% in 2000. The average household size is 5, similar to the national average. Its labor force is 59% and including farmers, the employment rate is 84%. Two ethno-lingustic groups make up Bakun's population. The Bago (literally translates to "new") are in Kayapa in the west. The Bago people are settled along the borders of the lowland province of Ilocos Sur and the Cordillera. The northern Kankanaey are in the six other villages of Bakun. This particular ethnic group dominates in the northern area of the province of Benguet and known to carve out terraces to build homes and farms from slopes to adapt to their rugged environment. Apart from the Bago and Kankanaey, there is a small percentage of people from other groups in the uplands and in the lowlands as a result of intermarriage and very limited internal migration.

3.3.1. Livelihood

Agriculture is the main livelihood in Bakun. Transient farmers work as laborers or as share croppers. Vegetables grown large scale include bell pepper, cabbage, Chinese cabbage, carrot, celery, cucumber lettuce, pole beans, potato, radish and sweet peas. Rice is grown for home consumption and for the local market. Similarly, subsistence crops planted on swidden or home gardens find their way to the local market. A small number is engaged in small scale industries like bamboo craft, furniture making, baking and loom weaving. Apart from agriculture, there are salaried employees in government service and private employment, as well as overseas employment. Other sources are small-scale livestock raising, retail trade, carpentry, hauling and transportation of vegetables. Depending on where they are in the municipality, some residents are engaged in small scale industries like bamboo craft, furniture making, loom weaving, mining and blacksmithing.

3.4. Drivers under study

A number of drivers of land use change (see diagram in the next page) have been identified, adapted from a formulation of proximate and underlying drivers of deforestation by Geist and Lambin (2002). The proximate or direct causes are road extension and improvement, permanent cultivation and colonization under agricultural expansion, and commercial logging, illegal logging and harvest from private woodlots and public lands under wood extraction . Historical incidents are considered by Geist and Lambin (2002) as underlying or indirect cause, but it is dealt with here as a proximate cause.

Direct causes are influenced by underlying factors, grouped here into demographic, economic, policy and cultural. The demographic factors are population growth and transient farming population; economic forces come from the mini-hydro power companies, employment and secondary sources, access to market and a market for subsistence crops. For example, a transient farming population in search of work or a share cropping arrangement can lead to agricultural expansion. In like manner, the financial contributions of mini-hydro plants in the area for infrastructure lead to road improvement and extension, thereby providing access and encouraging land conversion. The policies that were identified to have affected the direct causes are on timber extraction, decentralization and indigenous people's rights. The main cultural factor is customary land ownership, which affect wood extraction and agricultural expansion.

Under underlying factors are other influences that do not directly affect proximate drivers but may have a direct effect on land use. These extenuating factors contribute to no-change in land use, moderate or reverse the effects of the proximate causes of change. Out-migration, off-farm livelihoods and employment elsewhere, for example, means there are less people engaged in farming activities, and contribute to no-change. Also, logging ban and reforestation and the Community-based Forest Management Strategy of the forestry department will help restore degraded forest areas, and selective logging which is an indigenous forest management practices will help maintain forest cover and encourage revitalization of forests.

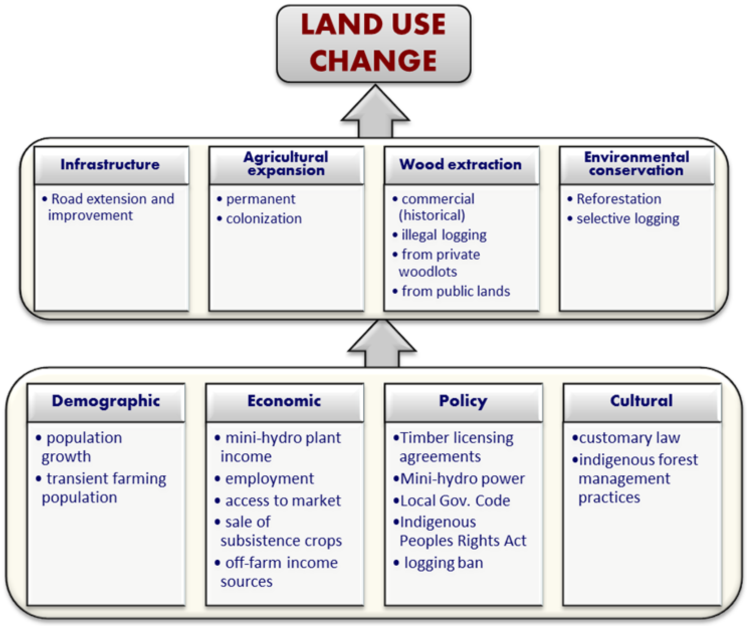

Figure 3.3: Drivers of Land Use Change

3.5. Methods to describe the drivers of land use change

3.5.1. Key informant interview

Knowledgeable key informants were interviewed on Bakun's past, their observations on current developments and perceptions on the future directions of the area in regard to economy, livelihood and governance. In particular, the former head of a people's organization and a community elder, municipal and barangay officials, heads and staff of offices, such as the planning, treasury, agriculture and local legislative offices branch secretary, lead persons in associations and direct implementors of an ongoing development project in the area, were interviewed.

3.5.2. Secondary data gathering

Secondary materials were gathered from the offices of the municipal government. Copies of past annual reports, blueprints of maps such as rivers, watershed and protected areas, alienable and disposable lands, the road network and an updated topographic map were provided by the planning office. Data on revenue collection came from the municipal treasury office and pertinent Memoranda of Agreement were shared by the municipal legislative office. Official statistical data from the National Statistical Coordination Board and mostly unpublished reports on past projects of the Department of Agriculture were also used (see Annex 1 for list of sources).

3.6. Materials to measure land use change

Primary and secondary data were collected from the field. Ground Control Points (GCP) for image classification and accuracy assessment were gathered from three villages. Remotely sensed data from three periods were likewise acquired for land use/land cover change analysis.

3.6.1. Ground control points

With the use of two Global Positioning Systems (GPS), GCPs of a minimum of 30 points were collected from key land use/land cover types in the area. To supplement this, sample points of a minimum of 30 points were also taken from Google Earth, specifically from a high resolution portion of the study area that was dated 15 April 2006 – 11 April 2010. As a result, over 50 points per land cover class in the analysis were generated.

3.6.2. Remotely-sensed data

One Landsat Thematic Mapper (TM) image dated February 21, 1990 and two Landsat Enhanced Thematic Mapper Plus (ETM+) dated April 3, 2002 and February 20, 2007 were acquired from the Global Land Cover Facility website. The 1990 and 2002 images were directly downloaded while the 2007 image was acquired through the ITC Remote Sensing and GIS Laboratory.

3.7. Methods to measure land use change

3.7.1. Image classification

The acquired remotely sensed data were rectified and a subset of the study area was taken from these using a digitized political map. Scanned blueprints and maps were rectified and registered to WGS 1984 UTM Zone 51N, the same map datum as the images. Pertinent data such as political boundaries, watershed areas, the river network and the road network were also digitized and created as map layers. The process of classifying remotely sensed data as described by Lu and Weng (2007) was adapted. "The major steps of image classification may include the determination of a suitable classification system, selection of training samples, image pre-processing, feature extraction, selection of suitable classification approaches, post-classification, processing and accuracy assessment" (Lu & Weng 2007: 825). Ground Control Points from the field and from known locations in Google Earth were used as sample to be used for the classification. A signature for seven classes, namely dense forest which includes both pine and lowland forest; open forest, characterized as sparsely forested areas (differentiated in terms of perceived density at the feature extraction stage), mostly pine and brush lands, open/cultivated land; rice/cultivated area, grassland, built-up area and water. A supervised classification was then undertaken with Maximum Likelihood as parametric rule. The results were improved through manual correction and mostly to replace shadows with the appropriate class. The above operations were carried out in Erdas Imagine 8.

3.7.1.1. Accuracy assessment

An accuracy assessment on the result of classification was carried out on the three land use maps using 210 randomly-generated points throughout the classified image using the 'equalized random' distribution parameters of Erdas Imagine. Accuracy assessments determine the quality of the information derived from remotely sensed data (Congalton & Green 1999) and an accuracy assessment is undertaken primarily "to derive a statement of classification quality on which to evaluate its fitness for purpose" (Foody 2009: 5274). The assessment was likewise carried out using Erdas Imagine 8.

3.7.2. Spatial analysis

Further analysis on changes was undertaken. Using the Spatial Analysis Tools of ArcGIS 2010, the land use maps were converted to shapefiles and intersected. The intersect operation generated a combined single map on the three periods with all their attributes. By comparing the attribute values in 1990 and 2007, changes from one class to any of the six other classes were identified. The most important ones based on total area of change were mapped. Also, to assess the effect of roads on land use, a 500-meter buffer was created and maps showing the differences in land use change within the buffer and outside the buffer were mapped.

3.8. Concluding remarks

The study area is an upland community in the western part of northern Luzon. The natural environment is characterized by a rugged, mountainous terrain with predominantly pine vegetation. Elevations are from less than 18% to 85% slope and elevation range from 120 to 2,625 masl. Itself a watershed, it has 4 river systems allowing for the tapping of the biggest river for hydro power generation. Its population is dominated by the ethnic group, Kankanaey, a forest dwelling group that has adapted to its environment by carving out terraces for agriculture. The municipality is well integrated in a cash economy, producing not only a variety of temperate vegetables but also subsistence crops including rice. Gambang and Poblacion are two of its seven villages that illustrate differences in development. Gambang is an upland roadside village engaged in commercial farming since the early 1940s; while Poblacion is an interior downstream, less-accessible village with a shorter history of commercial farming. It hosts two mini-hydro power plants thus has more local government resources than Gambang. They also differ in that Gambang farmers have more cash income than Poblacion residents.

The drivers of land use change to use in this study are grouped into direct or proximate causes, namely roads improvement and extension, agricultural expansion through colonization and permanent agriculture, and wood extraction, specifically commercial logging, illegal extraction, and harvesting from private woodlots and public lands, and conservation. Indirect factors that influence the direct causes are grouped into demographic, economic, policy and cultural. Remote sensing is used in a land use/land cover change analysis and GIS techniques were employed for spatial analysis.

4. THE DEVELOPMENT OF BAKUN AND CAUSES OF LAND USE CHANGE

This chapter is a narrative on the development of Bakun, but with close attention on the drivers of change, generally identified from the field work. It is divided into three main parts denoting important periods: (1) the history of logging in the area and the development of agriculture during the same time and an explanation on the changes in land use/land cover, (2) the imposition of a ban on logging, and (3) a new period of local autonomy, recognition of rights, and the use of hydrologic resources in the area. The list below is a summary of the main events described in the three phases:

Pre-TLA	:	Subsistence economy; evolution of indigenous forest management practices; past laws
1940s	:	Timber License Agreements (TLA) issued
1991	:	Logging ban on primary forests; on lands with elevation ≥1,000 meters, on slopes ≥50%
1990s	:	Entry of mini-hydroelectric power companies
1992	:	Implementation of the Local Government Code (LGC) of 1991
1997	:	Implementation of the Indigenous Peoples Rights Act
1998	:	End of commercial logging in the area
2001	:	Formulation of the Community-Based Forest Management Strategy

4.1. Some history

Prior to the entry of logging, Bakun was a subsistence economy. Livelihood activities were wet rice farming and swidden agriculture supplemented by fishing, hunting and gathering and small scale mining. Copper and gold were mined and used to exchange for salt, clothing, clay pots and blankets in the lowlands. Forests were well stocked, because use of timber was not exploitative. Lumber was taken mostly for house construction and, as there was no market for it, never harvested for sale. Dead trees and branches were collected for firewood. Whether trapping deer, collecting fruits and medicinal plants or taking cogon, the principle was always to get only what was needed for subsistence. Under customary law, people owned rice lands and woodlots, had use rights on swidden farms and held the other resources in the area in common. American colonial laws passed from the turn of the 20th century and other laws that followed under the Philippine government violated these rights and permanently altered use, access and ownership systems.

In 1902, the American colonial government passed the Land Registration Act and imposed the Torrens system of titling. This was followed by the Public Land Act of 1905 which declared that all lands unregistered under the previous Spanish colonial government and without Torrens titles were public lands and will be under State ownership and administration. In 1918, Public Land Act No. 2874 was passed allowing for the registration of lands through a free patent system. It prohibited titling on areas with metal or mineral deposits. It also excluded timber lands, because they are subsidiary interests of mines and are covered by other special laws (Tauli, 2009).

In Bakun, not too many people managed to acquire titles or free patents. Similar to other upland communities, many people did not know of these laws and if they knew, did not comply. Their security of tenure is based on customary land use and ownership laws; and owners of lands were known based on what lands they developed or used. Without their knowing, therefore, all unregistered lands had gone under the ownership and administration of the State. Much later, people placed their lands under tax declaration, acquired not only for taxation purposes but to provide a paper proof to customary land and protect themselves from losing them to others.

Meanwhile, two laws on mining were passed. The Mining Act of 1905 allowed "all public land to be free and open to exploitation, occupation and purchase by the citizens of the United States and the Philippines," while Commonwealth Act No. 137 or Mining Act of 1935 outlawed gold panning and native mining. These laws therefore as good as gave away indigenous land and livelihood to American prospectors. In Bakun, a mining exploration permit was acquired on Gambang in the 1930s and the mining company had built a road after the war to reach its claim.

In 1929, Proclamation No. 217 created the Central Cordillera Forest Reserve which covers 82% of the land that makes up today 10 provinces, including Benguet. This law also prohibits the cultivation of swidden farms within forests.

In 1931, the national highway linking Baguio City and Bontoc in Mountain Province was built. It traverses Bakun on the south along a ridge within the village of Gambang. Soon, a number of logging concession permits were granted on lands covering the length of this highway. Companies that were granted concession on Bakun arrived in the mid-1950s and one of them built a road from the mine exploration site in Gambang to Ampusongan. Meanwhile, people in Bakun began to move as well in search of work. Some left and found work as laborers in road construction, farms and mines; while households downstream maintained subsistence farming. Some of them will eventually go back to start work in their own farms since vegetable production was by then introduced also upstream.

Also from around the 1930s, grasslands were used for cattle grazing. Cattle was brought from the highlands to the province of Benguet and the practice during the Spanish period was to burn forest areas "to create pasturage and allow the establishment of newly introduced fruit tree and crops" (Poffenberger 1990: 59 in Colongon *et al.* (2004). Not all households were engaged in cattle raising, but those who did had from 10 to 20 heads, mostly sold for rituals and feasts.

4.2. Agricultural expansion

With the exception of La Trinidad, Bakun is one of the early participants of the vegetable industry in the province of Benguet. Commercial production of vegetables was said to have started in the municipality in 1948 in areas immediately along the Halsema Highway, all in the village of Gambang. It is known that "towards the end of the 19th century, Benguet potatoes and cabbage were sold in the Manila market, although as yet on a limited scale" (Scott 1977: 239 in Reyes-Boquiren (1989).

As the demand for vegetables from Baguio City and Manila increased, influenced to a great extent by Spanish, American, Chinese and Japanese entrepreneurs who provided the technology and the market, commercial agriculture intensified and production areas expanded. In Bakun, the village of Gambang was no longer the exclusive vegetable producing barangay as farmers in the other villages, whose activities that were once limited to the production of rice, sweet potato and taro for local consumption, gradually turned to more commercial farming. The expansion began first along the road to nearby Dalipey, then towards the east and into former concession areas (the history of logging is in sub-section 4.2). This shift "eventually integrated the local economy into the larger network of the capitalist system" (Reyes-Boquiren, 1989).

Land conversion for agriculture took place virtually everywhere. Abandoned logged-over concession areas in Gambang, Ampusongan and Sinacbat, which older concession holders abandoned, were claimed and converted for permanent agriculture. Continually expanding and in search of fertile lands as former areas became saturated with inorganic inputs, farmers moved into forested areas, used swidden for vegetable production and opened up grasslands. The rough terrain hardly posed a problem also as farmers built terraces of vegetable plots on steep mountain sides. It has thus become common to see by the 1980s vegetable gardens of all imaginable shapes and sizes along and way beyond both sides of the Halsema Highway. The landscape has become a collage of small patches of forest, grasslands, cultivated areas and settlements.

Meanwhile, companies that acquired logging and mine exploration permits on Bakun established their operations and opened roads in the mid-1950s and it meant jobs to some people. And where roads were built, agricultural expansion eventually followed. People settled on lands that had become accessible; and portions of private woodlots and clan forests were utilized for farming. This trend will become prevalent from the 1990s with the improvement and extension of roads.

4.3. Period 1: Commercial logging in Bakun

The history of commercial timber extraction in Bakun dates back to post-World War II and was fueled by the growth of the mining sector in the province of Benguet after the war. Ordinary Timber Licenses (OTL) and TLAs were issued by the then Bureau of Forestry to affiliates of mining companies. A TLA "is an agreement between the national government and a private person, natural or juridical, granting the latter the privilege to engage in logging activities, i.e. to cut and harvest timber, in a specific forested area under certain terms and conditions" (La Viña, 1990: 2 in (Colongon, et al., 2004). A TLA is good for up to 25 years; renewable to a maximum of 25 years.

The basis of the issuance of TLAs is the Forestry Act, promulgated by the American colonial government in 1904. This Act encouraged a rational exploitation of the forests by putting in place an appropriate regulatory environment, where fees and taxes were prescribed and parameters for conversion of forestland to agriculture were defined (FAO, 2001). Several TLAs were approved in the Cordillera and most were on indigenous peoples' domains. The fees, taxes and income had all gone to the national government and not shared with the local governments and the indigenous groups in the concession areas.

Four logging concessionaires held TLAs on Bakun for at least 50 years on roughly 24,000 hectares of forestland (Table 4.1). Only two of the seven barangays were spared, namely Bagu in the north and Kayapa in the west, which had no pine stands since it is a low-lying village. While other logging companies in the country exported lumber, those in Bakun mostly supplied the timber requirements of mines in the province. Given the scale of mine operations then, some thirty million board feet were needed per year. Aside from the mines, timber was also sold to the government from 1950 to 1956 during the construction of Ambuklao Dam in Bokod, a municipality in Benguet, and commercially to construction companies and stores.

Table 4.1: Logging Concessions in Bakun

Company	Period	Area (ha)	Barangays Covered
Itogon-Suyoc Mines	Pre-war	4,000	Gambang
Heald Lumber Co. (HLC)/BMC Forestry Corp.	1947 – 1998 (latest renewal in the 1980s)	10,216 - 14,000	Ampusongan, Poblacion, Gambang
Kairuz Logging	1950 – 1966	10,216 - 14,000	Ampusongan, Poblacion, Gambang (in the same area as HLC)
Lepanto Consolidated Mining Co. (LCMC)	1957 – 1995	~10,000	Lower Ampusongan, Dalipey, Sinacbat, Upper Gambang

Sources: Colongon *et al.* 2004; BIWDMP 2007-2017; Malanes 2005.

4.3.1. Presidential Decree (PD) No. 705

On May 19, 1975, Presidential Decree (PD) No. 705 or the Revised Forestry Code of the Philippines was passed. It mandated the following: adopt a multiple-use approach to forestlands, speed up land classification, delineate forest boundaries, rationalize wood-processing plants, improve forest protection and development through industrial tree plantations, conduct a census and recognize forest occupants, and continue to support the implementation of selective logging. This law also created the Bureau of Forest Development, which had the power to formulate and implement forest sector policies and programs.

Despite its advocacy on sustainable forest management, PD No. 705 actually paved the way for the issuance of more TLAs and unprecedented forest clearing. This law "reduced the focus on reforestation and rehabilitation of forestlands, and institutionalized the "timber-orientation" of many professional foresters" (Guiang, 2001). Logging peaked during the martial law years under Marcos, who granted rights to vast forest concessions to his favoured friends as a way to maintain political patronage since he came to power in 1965 (Pulhin, 1996; Vitug, 2000).

Like other laws in the past, PD No. 705 was not favourable to upland dwellers. Section 15 states that "no land of the public domain eighteen per cent (18%) in slope or over shall be classified as alienable and disposable, nor any forest land fifty per cent (50%) in slope or over, as grazing land." It further states that "lands eighteen per cent (18%) in slope or over which have already been declared as alienable and disposable shall be reverted to the classification of forest lands… to form part of the forest reserves, unless they are already covered by existing titles or approved public land application… and …when public interest so requires, steps shall be taken to expropriate, cancel defective titles, reject public land application, or eject occupants…" Upland dwellers in these exact locations thus rendered them squatters in their own lands. The national government largely ignored them when it issued or renewed TLAs and this law was invoked if upland people needed to be evicted.

4.3.2. Responses

The people in Bakun responded differently to the logging incursion. Some established their claims with paper documents, like free patents and tax declarations, but first had to clear their private forests so that their lands qualified as alienable and disposable, meaning non-forested areas fit for agriculture. Also, frustrated at the injustice of witnessing logging companies clear their forests while they were required to secure permits from the forestry department to harvest a few trees for house construction, the local people set fire on forests. Others eventually resorted to cutting the trees in their private forests and selling them to the logging companies. These cleared lands eventually became cultivation areas.

4.3.3. Reforestation under logging companies

As required by law, holders of TLAs were required to reforest their concession areas, and under PD No. 705, a silvicultural system for the Benguet pine species which grows in Bakun has been prescribed. As claimed by respondents, two early TLA holders abandoned their concession after harvesting all mature trees and destroying immature ones by dragging felled trees through them. Meanwhile, the two with the longest history in the area complied. The LCMC reforested with pine and introduced the tree variety, alnus, along roads for erosion control. The HLC, on the other hand, claimed to have reforested its concession area that had only originally had 43% forest cover, and attributed the afforestation of many areas within the concession areas to its reforestation and monitoring efforts over the years. Still, these companies benefited from second growth forests as they partly harvested just before the termination of their TLAs in the 1990s.

4.4. Period 2: Conservation and a ban on logging

Alarmed at the rate of forest loss and responding to pressure from the non-government sector, the DENR Department Administrative Order (DAO) 24 was issued in 1991. This law suspended logging from old growth forests yet allowed it in residual or second growth forests. Among other justifications, this directive was imposed to protect the critical watersheds or drainage areas of river systems supporting existing or proposed hydroelectric power facilities, irrigation works or existing water facilities in need of immediate protection or rehabilitation. Holders of TLAs were required to delineate and protect old-growth forests within their concession areas as part of their forest management functions.

In Bakun, there were no virgin forests left to delineate and protect. The same AO banned timber harvesting in critical areas with slopes ≥50%, on lands at elevations ≥1,000 meters above sea level, on up to 20 meters on both sides of stream banks and on wilderness areas primarily for conservation (Guiang, 2001). Despite these other restrictions, the logging companies in Bakun were able to harvest a limited amount from the second growth forests. The demand for wood has decreased with the mining industry on the wane. Many smaller mines were decommissioned and bigger mines were retrenching employees. Still, the logging companies harvested as much as they were able to until the termination of their TLAs. The ban also affected woodlot owners when they reclaimed their lands.

New TLA issuances were restricted, but in its place, the DENR formulated new instruments for forest resource access; among them the Industrial Forest Management Agreement (IFMA) as promulgated under DAO No. 99-53. The IFMA is a production sharing agreement in which the IFMA holder provides the resources for extraction and processing while the natural resources located in the IFMA is the government's counterpart. A maximum area of 40,000 hectares can be placed under an IFMA and the contract can last for as long as of 25 years, renewable for another 25 years. The profit sharing between the parties is usually negotiated and becomes part of the IFMA. Any TLA area can thus be placed in an IFMA and TLA holders applied for a conversion of their agreements, but there were weaknesses in actual conversion procedures or that many of the TLA holders that applied violated many provisions under their TLA, so were disqualified. In the end, only a handful of at most 200 applications were successfully converted by the end of 2002. In Bakun, one of the companies tried to apply for an IFMA, but strong community pressure against it prompted the DENR to reject the application. The opposition also had a strong basis with the awarding of a Certificate of Ancestral Domain Claim to the Bago-Kankanaey people of Bakun (see sub-section 4.8.1.1).

4.4.1. Immediate post-TLA period

When the logging companies left at the end of their TLAs, private woodlot owners reclaimed their lands while others staked new claims on communal lands under customary law. Much earlier, un-reforested logged over areas abandoned by the other logging companies were occupied and converted by farmers to permanent cultivation. It was the perfect opportunity since the vegetable industry was developing along the Halsema Highway at the time and farmers were in search of more lands to till. This was at least the case in the villages close to the Halsema Highway.

Much of the forested areas reclaimed by individual owners remained well-stocked for a while. Disturbed private forests were reforested by the owners with assistance from the Department of Environment and Natural Resources (DENR). Due to the ban on logging and PD No. 705, owners were only allowed to harvest enough trees from their private woodlots or the communal forests to build their homes. No other benefits were derived for maintaining a forest land use and most people had maintained relatively small-scale production areas within their properties. Gradually, however, with no alternative livelihoods to pursue and the relative profitability of producing vegetables, especially with a these forested private woodlots were cleared for agriculture.

Illegal logging in the area intensified in the immediate post-TLA period. Loggers were known to have colluded with some government field personnel to log in forested former concession areas, and bribed authorities manning check points to reach their market, primarily individuals, carpentry shops and construction companies in Baguio City and La Trinidad. Guiang (2001) had observed that "the cancellation, non-renewal, and suspension of TLAs increased open access and contributed to illegal logging and cutting, and have greatly added to the loss of forest cover" (p. 18). Eventually, however, all lands in Bakun became private properties or delineated as government lands.

4.5. Period 3: Environmental conservation, economic development and autonomy

Following the ban on logging and the slowing down of some activities in forestry were many developments in the other sectors of government. The newly created Department of Energy (DOE) was developing its various sub-sectors including mini-hydroelectric power production. The decentralization law was also enacted and implemented, and advances in recognizing indigenous peoples' rights were taking place.

4.5.1. Mini-hydroelectric power production in Bakun

The potential for mini-hydroelectric power generation was established in the province of Benguet from previous assessments done by both government agencies and private companies, and from 1991, a number of laws were passed in support of this sub-sector, increasing the opportunities for the private sector to participate and defining the incentives to communities that participate. Bakun hosts three mini-hydro plants and a 10-kilometer conveyance tunnel to direct water to another mini-hydro plant just outside its western border and at the convergence of two river systems from Bakun. All these mini-hydro projects are now owned and managed by Hedcor, Inc., a self-proclaimed producer of clean energy and the largest developer of run-of-river hydropower in the Philippines.

In 1991, the Northern Mini-Hydro Corporation (NMHC) built the 5-megawatt Ferdinand L. Singit (FLS) power plant and the 2.4-megawatt Lower Labay power plant in Barangay Sinacbat. Towards the end of 1993, it built the 3.6 megawatt Lon-oy Power Plant in Barangay Poblacion. These three inter-connected plants are referred to as the Bakun Grid and together contribute a third of the company's total capacity of almost 35 megawatts from its 13 mini-hydro power plants in the province of Benguet. In 1996, Bakun agreed to support the installation of conveyance tunnels for the 70-megawatt Bakun AC power plant by another company, the Luzon Hydro Corporation (LHC). This power station is the first hydro project under the government's Build-Operate-Transfer scheme.

The partnership terms between the mini-hydro companies and the Local Government of Bakun are contained in Memoranda of Agreements and are in effect for 25 years; renewable for another 25 years. The latter made a commitment to protect the watershed, ensure peace and order, and cooperate with the management and the plant staff. The barangays where the plants are located also signed resolutions of support.

The energy produced by the Bakun Grid is delivered and taken up by the NPC and the Benguet Electric Cooperative (BENECO), while the Bakun AC production is delivered and taken up solely by the NPC, in turn dispersing it to its Luzon grid.

4.5.1.1. The Bakun Grid financial contributions

Based on municipal treasury records, Hedcor has been complying with the terms of the MOA. It has been paying the stipulated 2% share of the municipality and the 1% share of the barangays from the sale of electricity. In 2009, the total contribution to the municipality reached 52.52 million pesos and to the barangays, 26.26 million pesos. The usual taxes were also paid annually, in which total Real Property Taxes paid from 1993 to 2009 totaled 49.564 million pesos and Business Taxes from 1991 to 2009, 5.877 million pesos. These collections belong to the barangays that host the hydropower plants. Meanwhile, Privilege Taxes amounting to 38.6 million pesos for the period 1992 to 2009 were paid to the Bureau of Internal Revenue. This enters the national coffers and expected to be received by the LGU as part of its Internal Revenue Allotment, its share in the national income to manage its devolved functions.

4.5.1.2. Contributions for road improvement

In terms of infrastructure development, Hedcor has undertaken road rehabilitation projects over the years from the road junction in Barangay Gambang along the Halsema Highway to Barangay Ampusongan, the current seat of municipal government. It also built a road from Ampusongan to Lower Labay where one of its plants was built. Over the years, it maintained this road and also provided an annual support to augment municipal funds for road rehabilitation anywhere along the Gambang-Poblacion stretch. In 2009, it donated 3.9 million pesos for road rehabilitation within the Ampusongan-Poblacion stretch, which includes a portion of the municipality of Kibungan.

4.5.1.3. Reforestation support

As mandated by law, mini-hydro companies contribute to the Reforestation, Watershed Management, Health and/or Environment Enhancement Fund under the DOE. While contributing to this fund, Hedcor has also provided support for reforestation directly to the communities. Key informants claimed that the company provided fruit tree seedlings, like mango, citrus, and coffee to interested farmers and occasionally distributed pine tree seedlings. These were planted in private woodlots, swidden farms and communal forests.

4.5.1.4. Rent and privileges of landowners

In addition to its commitments to the municipal government, Hedcor also pays rent to landowners on whose lands transmission lines and towers have been installed. There are about 30 towers within the grid and as claimed by a key informant, there are 64 identified landowners excluding the local government who lease their tax declared lands to Hedcor at different rates, from 0.50 centavos to 2.50 Pesos per square meter, depending on land use. This rent was said to have been increasing by 5% every 5 years since 1991, and the contract will end in 2017. Landowners are also being paid by the company to maintain the offered contractual jobs 7-km road leading to the Lower Labay Plant and get the first offer on contractual jobs, like hauling of aggregate materials or transmission line materials.

4.5.1.5. The Bakun AC power plant payments as mandated by law

The LHC has been paying the regular annual taxes as required by law. Based on municipal treasury records, LHC has paid 17.6 million pesos in Real Property Taxes from 2002 to 2009 and almost 9 million pesos in business taxes from 2005 to 2009. As for NPC, it paid in 2004 the amount of 3.2 million Pesos to Bakun and so far about 2.5 million pesos to the barangays as their share in the National Wealth Tax (Cadiogan & Bangaan, 2007). In the Municipal Treasurer's report in 2009, 4.73 million pesos was paid by NPC to Bakun.

4.5.1.6. Contributions for road improvement and reforestation

Since it began its operations, the LHC made financial contributions for road improvement to augment municipal funds; and as observed by the local officials of Poblacion, the entire stretch of road from

Ampusongan to Poblacion will soon be paved with the contributions of both companies. The LHC also worked with the DENR, peoples' organizations and the local government.

Table 4.2: Reforestation Contracts with the Luzon Hydro Corporation

Location	Area	Cost (in pesos)	Duration
Sinacbat	100.00	2,864,602.22	2003-2005
Poblacion	90.0	3,756,408.80	2004-2006
Poblacion	51.50	2,230,008.95	2007-2011
Dalipey	8.00	356,316.37	2007-2011
Kayapa	24.0	1,140,934.08	2007-2011

Source: LHC (2003) in BIWDMP 2007-2017

4.6. Local autonomy

A new government structure was put in place in 1992. Republic Act No. 7160 or the Local Government Code of 1991 decentralized governance by devolving some structures and processes to local government units (LGUS), namely provinces, municipalities and barangays. It gave LGUs the task of developing their plans and programs with their citizens; it opened avenues for greater civil society participation, such as representation in local councils and sectoral committees; it handed down the task of basic service provision, specifically in education, health and social welfare; and also assigned the task of implementing development projects. Also devolved were agriculture and, to a limited extent, environment and natural resource management functions.

To support their devolved functions, LGUs get a share of the national internal revenue taxes (Section 284) in the form of Internal Revenue Allotments (IRA). The allocation for local governments is 40% of the total national income and is distributed among the LGUs based on land area, population and equal sharing. From its allocation, a LGU can use up to 20% for development projects (Section 287). Apart from the IRA, LGUs receive an "equitable share in the proceeds derived from the utilization and development of the national wealth, such as minerals, forest resources, marine resources and water resources within their respective areas" (Section 289).

The Code also gives LGUs taxing and revenue-raising powers (Section 128). The imposition of major taxes such as customs duties, taxes on income, sales, and excises is reserved to the central government, but LGUs can collect taxes from various sources such as from real property, business, franchise, amusement, documentary stamp and on estates, inheritance, gifts, legacies and other acquisitions. Non-tax revenues come from regulatory fees, user charges and other receipts, such as contracts with the private sector for projects or other commercial undertakings within the LGU.

4.6.1. Local government share from power generation

In addition to its internal revenue allotment, Bakun generates significant amounts of real property, business and privilege taxes annually and some of the national wealth tax from the mini-hydro power companies. Aside from these regular taxes, it also generates a special income from the share of the sale of power.

Also under the law, LGUs have an equitable share in the proceeds derived from the utilization and development of the national wealth within their respective areas, including sharing the same with the inhabitants by way of direct benefits (Section 289, Chapter II, Book II). The national wealth tax is computed as either 1% of the gross sales or receipts of the preceding calendar year; or 40% of the mining taxes, royalties, forestry and fishery charges and such other taxes, fees or charges, including related surcharges, interests, or fines the government agency or government -owned or -controlled corporation would have paid if it were not otherwise exempt" (Section 291, Chapter II, Book II). Other taxes due the local government include a franchise tax, and privilege taxes payable to the Bureau of Internal Revenue, but to be remitted to Bakun as part of its Internal Revenue Allotment.

The share of Bakun from power generation since 1990 was 52.516 million pesos, while Barangays Poblacion and Sinacbat have shared 26.258 million pesos. These amounts are not administered separately and are utilized as part of IRA. As such, these incomes contribute to funding government operations and development projects prioritized by the local government units. Contributions are made to infrastructure development, such as the construction, repair or improvement of farm-to-market roads, bridges, foot paths or communal irrigation systems. Poblacion earns at least 1.5 million pesos more than the other barangays. Its higher income has improved the delivery of services, for example in education where an extra teacher is hired. Barangay functions were also said to have greatly improved with the hiring of an engineer and a bookkeeper. The other barangays, on the other hand, transact with the municipal engineers and bookkeepers. As allowed by the LGC, the salaries of local government officials are also higher in Poblacion as compared to the others.

Based on fiscal performance, LGUs are ranked from 1st to 5th class. Given its income level, Bakun was elevated to the rank of 3rd class municipality. In the province, it leaves behind seven other municipalities and follows four that are far richer due to their being host to mines or dams. Three are also located within the Baguio City area which is causing their urban transformation.

4.7. Roads extension and rehabilitation

The current state of Bakun's road network is a result of an infrastructure development effort by the municipal government which aims to link the barangays not only to the municipal center but also to other points outside the municipality, the most important of which is the market for agricultural products. As of 2007, there were 50 road sections with a total length of 243.8 kilometers. There are four kinds of roads within Bakun, namely the national road in the southeast, the secondary national road going down to Poblacion which is the municipal center, provincial or municipal roads coming from the secondary national road, and barangay roads.

The secondary national road going down to the southwestern village of Ampusongan where one sawmill was located was unpaved for a long time. In 1972 at the initiative of the municipal mayor, a dirt road was constructed to reach Poblacion, but for lack of maintenance, was eventually closed. In 1976, the Heald Lumber Company re-opened it to facilitate its entry into some parts of the concession area, but this was again eventually closed when the local government was not able to maintain it. In 1989, this was re-opened by the NMHC along with a new section to reach its power plants northeast of Poblacion.

The LHC had also helped maintain the road to Poblacion during the construction of its conveyance tunnels and transmission lines and donated a loader for road maintenance to the local government as part of its commitments. More road maintenance support was provided and along with local government and national funds, sections of the main road were paved. Concrete tire paths or farm-to-market roads were also built with support from the national government, allowing farmers access to the market and their farms, but also the opportunity to move towards forested areas to expand their cultivation areas.

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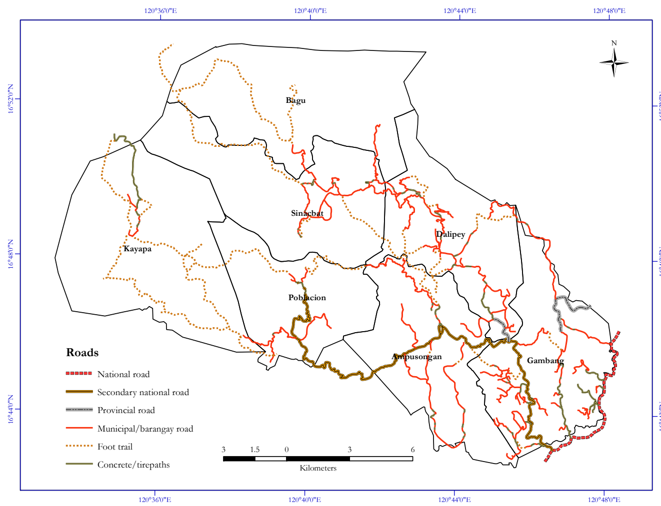

Figure 4.1: Bakun Road Network

4.8. Recognition of indigenous rights

A strong support from the civil society sector for the recognition and promotion of the rights of indigenous people's resulted to the inclusion of provisions in the 1987 Philippine Constitution. Sections 31 and 32 require the State to create a policy "to recognize and promote the rights of indigenous peoples/indigenous cultural communities within the framework of national unity and development (and) to protect the rights of indigenous cultural communities to their ancestral lands to ensure their economic, social and cultural well-being."

4.8.1. Department Administrative Order No. 2 Series of 1993

While an enabling law on indigenous peoples was being debated and crafted, the DENR issued Department Administrative Order No. 2 Series of 1993 titled "Identification, Delineation and Recognition of Ancestral Land and Domain Claims. It details how an eligible individual or group can acquire a Certificate of Ancestral Land Claim (CALC) or a Certificate of Ancestral Domain Claim (CADC). It requires an applicant to comply with various requirements including proof of use and occupation of a territory since "time immemorial." A CADC gives a recipient indigenous group the right to claim its ancestral domain and utilize it to serve the interests of the domain members. Meanwhile, DAO 96-34 contains the Guidelines for the Management of Ancestral Land and Domain Claims. It requires an applicant to submit a plan in which its vision, programs and plans are to be contained.

4.8.1.1. Effect on Bakun

Both laws were beneficial to Bakun. Facilitated by its organization, the Bakun Indigenous Tribes Organization (BITO), a plan was prepared, thrusting the people of Bakun into a process alien to most of them. Their indigenous system of *tongtong* or dialogue aided in the crafting of their vision, the identification of their problems, the prioritization of their plans for the future and forced them to codify their indigenous knowledge, systems and practices.

All pertinent documents for a CADC application were also prepared and submitted to the DENR. On March 18, 1998, a CADC was awarded to the Bago-Kankanaey people of Bakun. By then, however, the Indigenous Peoples Rights Act was signed into law and required Bakun to seek a conversion of its CADC to a Certificate of Ancestral land Title (CADT) and to prepare a plan called Ancestral Domain Sustainable Development and Protection Plan (ADSDPP). Nonetheless, the CADC effectively allowed the people in

Bakun to reclaim their private woodlots and prevented the application of the Heald Lumber Company to convert its TLA into an IFMA (see sub-section 4.4).

4.8.1.2. The revival of the *papangoan* and the system of *tongtong*

In the midst of the debates going on regarding recognition of indigenous rights, Bakun, independently, initiated the revival of its indigenous leadership structure and dialogue system. In the Bago-Kankanaey society, a council of elders is constituted and tasked to make major decisions for the community. Called the *papangoan*, it is made up of men and women with acknowledged leadership and who are held in high esteem in the community. This body hears, reviews, decides and settles disputes and conflicts within the village. It also metes out fines and penalties on offenses requiring them. Settlement of disputes is handled by these leaders through a system of dialogue called *tongtong*. This is a justice system based on consensus. The *papangoan* and the *tongtong* are known to be as old as the first settlers of the domain. A modern-day *papangoan*, now called the council of leaders, was reconstituted in the 1980s. Its composition is wider, but basic requirements for members are the same. While a formal legal system is now in place, this body still hears and settles disputes and basically gives the people of Bakun an alternative avenue to seek justice for offenses committed on them.

4.8.1.3. The Bakun Indigenous Tribes Organization

Following a requirement in the DAO 2 for an organized indigenous peoples group that will become the recipient of the CADC and who will be tasked to implement projects, the people of Bakun constituted themselves into a formal organization called the Bakun Indigenous Tribes Organization (BITO). It had 1,700 registered members in the beginning, but it was assumed that every Bago or Kankanaey person living in the domain is represented by the BITO. Beyond this practical reason, the formation of the BITO was an effort to consolidate the traditional village councils in the domain.

Upon it formalization, the BITO became the mechanism in which the Bago and Kankanaey people worked collectively (Malanes, 2002). This organization led in organizing the domain members to develop the ancestral domain plan and codify their indigenous knowledge, systems and practices, and to prepare the people for the role of managing the domain within a setting far removed from their ancestors' beginnings, BITO led in domain-wide advocacy, capacity building, reforestation, planning, cooperative formation, functional literacy training and has set up a revolving fund for livelihood projects. It involved women as forest guards who worked closely with the village leaders and the forestry department in protecting the forests. From 1998 to 2002, this participatory development effort was supported financially and technically by the International Labor Organization's Inter-Region Programme to Support Reliance of Indigenous and Tribes Communities through Cooperatives and Self-Help Organizations (ILO-INDISCO). From these experiences, the BITO has become a strong organization whose voice is heard today in the local government council and in other venues of planning and implementation aimed at protecting the environment and improving the socio-economic status of BITO members.

4.9. The Indigenous Peoples Rights Act

Republic Act 8371 or the Indigenous Peoples Rights Act was signed into law in 1997 and dissolved the DAO 2. The failures of a centrally directed governance system are what this law aims to rectify. By recognizing prior or vested land rights, traditional use rights, and persisting cultural practices, IPRA favours the indigenous peoples by recognizing their authority to manage all natural resources within their ancestral domains (Boquiren, 2004). The IPRA allows individually owned ancestral lands used for agricultural, residential, pasture, and tree farming purposes, including those with a slope of 18% or more, to be classified as alienable and disposable agricultural lands (Section 12). This right therefore invalidates the provisions of PD No. 705.

The CADT on Bakun was awarded on July 20, 2002, a historic moment as it was the first title ever awarded in the country. The CADT was a reiteration of the people's claim to their ancestral properties. The area of the ancestral domain is the same area as the municipal political boundary. A plan was also prepared with assistance from the National Commission on Indigenous Peoples, the agency created to implement the IPRA. This plan reiterated the people's adherence and willingness to practice and promote their sustainable forest management practices. A short summary of indigenous forest management practices follow.

4.10. Indigenous forest management practices

The Bago and Kankanaey groups developed their indigenous knowledge, systems, practices and technologies on resources and resource management, and they considered themselves mere stewards of their domain and resources. Under the terms of the CADT, the people invoked their indigenous system of ownership, such as in their claim on woodlots. On managing their lands, they have also resumed old practices in forest management practices. (*Bakun Ancestral Domain Sustainable Development and Protection Plan (ADSDPP), Bakun, Benguet.*, 2004; Malanes, 2002; *Participatory Baseline Survey Report of the Bakun Indigenous Tribes Organization* 1998).

4.10.1. Land ownership

Private ownership of lands is now supported by tax declarations and free patents, but before paper titles, people had use rights over swidden farms. Under customary law, members of the indigenous group own woodlots, residential lots and rice lands. The woodlots are the same forests put under logging concessions in the past. Almost all private woodlots are pine, while watershed areas are montane, pine or lowland forests. Owners of private woodlots in general have the right to convert their lands to other uses, but are restricted by both the ban on logging and customary law. Despite the restriction and with limited lands for farming, a very lucrative market for agricultural products and limited sources of livelihood, these forested lands are still cleared for agriculture.

Paddy fields are private properties and are absolutely not for sale to outsiders. These can be mortgaged, first to close family relatives, otherwise to clan members. This is to make sure that the property remains within the clan in the event that it cannot be recovered by the owner. Communal lands awarded to local governments had been reclaimed by previous owners. Those remaining and protected areas are under the protection and management of the barangay governments. Irrigation systems are communally owned and managed by groups of paddy field owners of contiguous rice farms. Residential properties are under tax declarations or free patents and, like paddy fields, can only be sold within clans, otherwise to community members. Land can be rented out, as is a common case in the major vegetable producing villages.

To date, all lands in Bakun are either under private ownership of individuals or clans. These are ricelands, residential properties and woodlots. The proof of ownership is now a tax declaration or free patent document. These paper titles are both for taxation purposes and an assurance against appropriation by other people or the government.

4.10.2. Private woodlots

Within customary law, a family or clan can privately own a woodlot called *muyong*. Only members of the clan or family are permitted to harvest from the woodlot. The right amount of wood for house construction and other forest products for subsistence purposes are among those that are allowed. When needed, non-members were permitted by owners to extract resources from the woodlot as well. These may be firewood for a community feast or a tree of specific size and maturity to make a coffin. As part of the management of these woodlots, families may replant and restock the woodlot with the same species. Clearly, this indigenous system preserved the forests before commercial logging.

In the past, also collected from the *muyong* is fuel wood. Gathering of fallen twigs and branches is allowed, also since it is a good forest management practice. Collecting the lower branches from trees, called *tadaw* is encouraged as a mechanism to prune and train the growth of trees, since these will be harvested later as timber. Dependence on fuel wood is so much reduced now, since most households use gas stoves.

Harvesting of forest resources from the *muyong* is also now governed by government rules. By acquiring the required permit from the DENR, the endorsement of the barangay government, paying the necessary dues and making a commitment to replant, a family is allowed to harvest enough from one's *muyong* to build a new house or repair an old one.

In the past, use of lumber was restricted within Bakun, but such is no longer strictly imposed today. By complying with local ordinances, as well as providing proof of ownership to the DENR and the Philippine National Police, a family can transport enough lumber for a new home to another location, such as Baguio City and La Trinidad where many Bakun families have built second homes. Also, a family has to raise enough money to pay the high fees imposed by the DENR on tree cutting and transporting of lumber. In general, the process is long and tedious as claims are verified and requests take long to be acted on.

4.10.3. Communal forests

Many of the forests in Bakun are communally owned and managed. This means that no single person or group can claim exclusive right to their use. They are allowed, on the other hand, to harvest trees and other forest products after acquiring and being granted permits from the barangay government with proper notification to the local Philippine National Police station officer and the issuance of yet another permit by DENR. Use of harvested products is likewise restricted.

Similar to *muyong* rules, permits are granted for collecting firewood or cutting trees for a feast. Every person instead has certain responsibilities, which includes helping to guard against indiscriminate cutting of trees, encroachment, or other destructive acts. The Bureau of Forestry recognized these communal properties and in 1935 to 1937, officially delineated nine of them as community forests and prescribed allowable uses. To date, these communal forests are managed by the barangay governments who put in place local ordinances to restrict access and use.

Unfortunately, most of these community forests are no longer functioning as such. Key informants claimed that most of these were claimed by private individuals who have since converted the lands for agriculture and settlement and that the barangay governments did not verify claims of prior ownership thus making it possible for tax declarations to be acquired on these lands. The limited amount of monitoring especially in areas that were inaccessible made it possible for the conversion of forests to agriculture or the illegal cutting of trees to take place.

Meanwhile, "watershed" areas are delineated in each village as primary sources of domestic water. Under the management of the barangay, no activity is allowed in these areas in general. Some of these areas were locations of reforestation projects in the past. Figure 3.2 also shows the delineated protected areas.

4.10.4. Other forest protection practices

Individually or collectively, the people of Bakun perform regular management activities to protect their woodlots, communal forests and watershed areas. The following are some of those still practiced:

- ✓ Reforestation
- ✓ Regular cleaning. Fire-prone areas, as well as established fire lanes are cleaned to prevent the spread of spontaneous, unintended or deliberate setting up of fire in the forests.

- ✓ Stone walls or mud ramparts are built to control erosion mostly along gullies and in steep erosion-prone areas.
- ✓ Planting of deep-rooting trees across slopes for erosion control.
- ✓ Digging of trenches to divert runoff water from erosion-prone areas and avert erosion
- ✓ Planting of firebreak plants, like maguey, an agave plant. It is good for controlling erosion and thrives in grasslands of sparse pine forest environments.

4.11. DENR's Community-Based Forest Management Strategy (DAO No. 96-29)

Many of the reforestation activities in Bakun were assisted by the DENR directly or as required by at least one forestry directive, such as the reforestation activities of the logging companies in the past and citizens who have taken over their private forests have received seedlings from the DENR. The hydro companies have also supported reforestation activities in addition to the requirement to contribute to a watershed protection fund.

While part of the management of natural resources have been devolved to local government units, the DENR is still the agency primarily responsible for formulating policies and implementing programs on environment and natural resources. In forestry, it now advocates and implements projects using the Community-based Forest Management approach, currently the country's national strategy for sustainable forest management. Past forestry programs and projects of the DENR are all subsumed under this law. It is an integrated approach to build the capacities of people's organizations, local government units, non-government organizations and other agencies to become partners of government in managing, developing and protecting the country's forest lands.

In 1986, it implemented the Integrated Social Forestry Program in 4 villages in the upper Bakun area. Under this program, land owners committed a part of their land for reforestation and agroforestry for a period of 25 years. In return, they received a package of incentives, in the form of agroforestry seedlings, livelihood and technical support. After the seedlings were distributed and participants were assisted to plant, no other support was provided, such that eventually some of the individual projects failed. The lands were then reverted or converted to agriculture. Others later decided to clear their tree plantations and use the land instead to agriculture since rewards from vegetable crops was higher than from a small number of fruit tree crops occupying the same area of land.

From 2000 to 2004, the DENR led in the implementation of a reforestation program in Bakun under a bigger Asian Development Bank-funded project called Cordillera Highland Agricultural Resource Management (CHARM) Project. It engaged five local peoples' organizations to reforest a total of 438.50 hectares within communal forests and private lands in five villages (Table 5.5). The project had a capability building component wherein the members of the peoples' organizations were taught not only nursery management, planting, monitoring and maintenance skills, but also organizational and financial management skills.

Table 4.3: Reforestation Projects (2003-2006)

Location	Area (ha)/Land Ownership	Implementing Organization
Ampusongan	76.5/90% Communal forest	Ampusongan Women's Club
Gambang	57.0/Tax Declaration	Gackian-Mabuhay Irrigators' Association
Kayapa	60.0/ Tax Declaration	Kayapa Bakun Farmers and Irrigators' Assoc.
Poblacion	125.0/ Tax Declaration	Poblacion Saguday Foundation, Inc.
Sinacbat	120.0/ Tax Declaration	Sinacbat Farmers' Association
Total	438.50	

Source: BIWDMP 2007-2017

4.12. Special projects

After the ILO-INDISCO project, the CHARM Project made a few villages in Bakun among its project sites. From 2000 to 2004, this project provided a package of projects, among them capacity building activities, support for the conversion of the CADT and support to formulate the ADSDPP. From 2004 to 2007, the municipality of Bakun also became a pilot project under the program called RUPES (Rewarding Upland Poor in Asia for the Environmental Services they Provide). Funded by the International Fund for Agricultural Development (IFAD), it aimed to test models of practices on environmental transfer agreements and Bakun was chosen as a model site because of the presence of major environmental users in the municipality, namely the hydroelectric companies and because of its special position as the first holder of a CADT. It was a special case also in which to test how the IPRA can provide better opportunities to maximize the decision-making powers that the people of Bakun have received with their CADT and allow them to participate in designing mechanisms to sustainably utilize their resources that is equitable and beneficial to the domain members. This project introduced people to valuation, payments for environmental services and assessments of their poverty situation and their natural resources, particularly hydrologic resources.

4.13. Demographic changes

The average growth rate in the municipality from 2000 to 2005 was 3.2%. The total dependency ratio was 40.60% and its labor force made u 59.36%. Including farmers, the employment rate was 84%. As already explained in the previous chapter, the main livelihood is farming. Residents operate their own farms, engage in share cropping or work as laborers. In-migration is evident in barangays where agriculture is relatively large-scale and where there are employment opportunities and social services. Gambang has the biggest migrant population as people from nearby municipalities or the lowlands settle there permanently or temporarily to farm. Ampusongan being the seat of government has all the health, social welfare, and education facilities, so is also a migration area to people from the other villages.

The municipality of Bakun was created in 1963 by virtue of Executive Order No. 42. Four of its current barangays were places that belonged to different politico-military commands as early as 1852 under the Spanish regime. In the census year prior to its creation, it had a population of 4,927. That number would increase to 6,584 in 1975, eventually reaching 12,137 in 2007. The only significant decrease in population was between the period 1995 and 2000. This can be explained by the closure of the sawmills and the eventual withdrawal of the logging companies within this period. The transient workers and their families may have moved out of Bakun with no alternative employment or livelihood opportunities.

Table 4.3: Population distribution in Bakun (1960 – 2007)

Year	Population	Increase/Decrease (No.)	Increase/Decrease (%)
1960	4,927		
1975	6,584	1,657	33.6
1980	8,878	946	34.9
1990	10,817	1,939	21.8
1995	12,836	2,019	18.67
2000	12,213	-623	-4.9
2007	12,137	-76	-0.6

4.14. Employment and multiplier effects

Up until 1990, off-farm jobs in the municipality were very limited. Most of the households were engaged in farming and other land-based livelihood activities, and a very limited number were employed as government workers, public school teachers and administrators and employees of the logging companies. Many families left to find work in road construction, in the mines located in neighboring municipalities and in the service sector in urban areas.

Employment was provided later on by the mini-hydro companies. Construction workers were employed to build roads and the three mini-hydro power plants from 1990 to 1993. To manage these plants, at least 30 individuals are employed as operators, mechanics or watchmen. In addition, land owners whose properties were being rented by the Hedcor were being paid to maintain the road that it built and occasionally offered contractual jobs such as hauling. From 1996 to 2001, a 600-man pool worked to improve and maintain roads and to construct a 9.6-kilometer conveyance tunnel, power transmission towers and a mini-hydro power plant. Majority of the laborers were from Ampusongan, Poblacion and Kayapa. Meanwhile, municipal government employment increased in 1992 when the Local Government Code was implemented. Devolved functions in education, health, agriculture, social welfare and infrastructure provided residents with the appropriate qualifications to be employed in their municipality.

Employment in the mini-hydro constructions meant less work on-farm. At the end of their contractual employment and with no other alternative sources available, many went back to farming.

There were not enough jobs for a growing population of professionals. A search for jobs took many of them to Baguio City and other parts of the region, such as in mining communities and where they eventually permanently relocated.

With salaried households, other livelihood activities emerged. Enterprising women established retail stores to sell basic household needs. Many of them managed to start a small business from the income of household members employed in the hydro projects. To date, there are 26 of these stores still in operation in Poblacion alone. Many other livelihood activities also increased, such as in house construction and transportation.

A common perception in the area is that people are still poor, not only because there are not enough jobs for everybody but that even if they were engaged fully in agriculture, their levels of income remain low because of the terms of share-cropping or prices controlled by bigger farm operators. It is also due to the presence of middlemen who provide inputs to farmers and later get repaid handsomely by imposing very low prices on farm products.

4.15. Summary

The municipality of Bakun developed from a subsistence economy to a cash economy. Policies on resource use started from indigenous law that espoused moderation and conservation, to a national law that allowed massive timber extraction, later followed by another national legislation that restricted further exploitation, and currently to a policy mix of local autonomy, recognition of indigenous rights and promotion of indigenous knowledge systems and practices and a new arrangement of benefits sharing on the use of hydrologic resources.

5. LAND USE/LAND COVER CHANGE ANALYSIS

The events in the area previously described have resulted in land use/land cover changes. This chapter presents the results of a land use/land cover change analysis within a 30-year period, from 1977 to 2007. Two land use maps from a previous study were used to present changes between 1977 and 1987 while three Landsat satellite images dated 1990, 2002 and 2007 were classified and compared. The results of the classification per year are presented with a summary of actual area per class per year. A discussion on two villages of interest follow to highlight differences in change through the years, then ends with the results of spatial analyses on the most significant changes from forest classes to other classes and on the effects of roads to land use change.

5.1. Spatial changes within the logging period

Two land use maps that were sourced from an unpublished report (Cruz, Suminguit, & Folledo, 2005) show the amount of change in land use/land cover in the area (Figure 4.1). The 1977 land use map was derived from a NAMRIA topographic map with a scale of 1:50,000 while the 1987 map was classified from a Spot TM satellite image. Only 69% of the area of the study area, however, was classified but comparing this against the current political boundary, the excluded portions were the villages with no logging activities. Also, classes were not uniform; still the results showed a clear change, which is the reduction in the area of pine forest in 1977 and a significant increase in the area of brushland in 1987. Grassland was also significantly reduced from 1977 to 1987, likely a result of increase in vegetation and which further increased brushland.

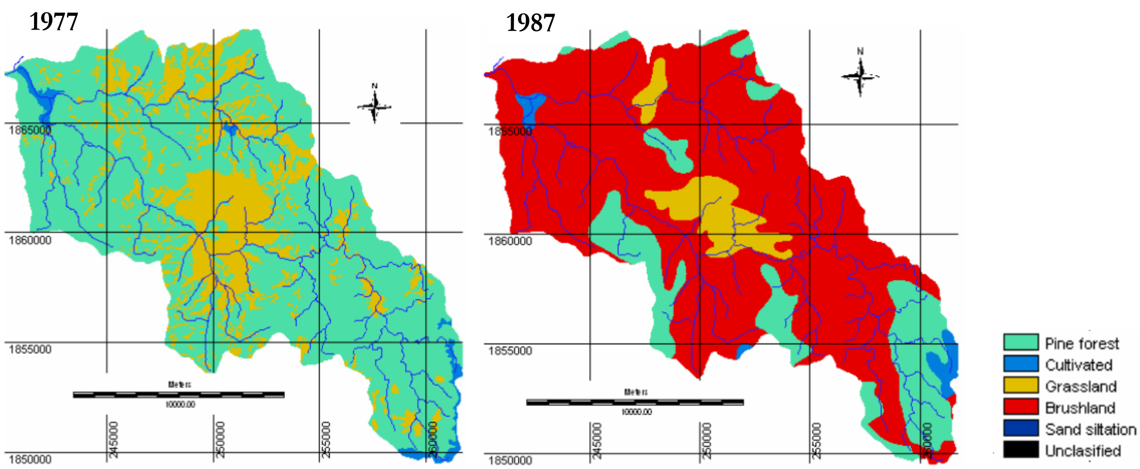

Figure 5.1: Land Use Maps of Bakun (1977 and 1987)

Table 5.1: Distribution of Area by Class (1977 and 1987)

Land use/land cover class	1977 Area (ha)	1987 Area (ha)
Pine forest	15,854	3,729
Cultivated	396	381
Grassland	4881	1,336
Brushland	0	15,685
Total	**21,131**	**21,131**

Cultivated lands in both periods were very small at less than 400 hectares each year. The area seems too small considering that all the villages at the time had rice fields and two villages in the south were producing vegetables. The land use map of 1987 clearly does not show that there are plots inside the forests, indicating that swidden farms were not separated and measured.

5.2. Definition of classes

Seven classes were created representing dense forest, open forest, grassland, open area/cultivated land, rice/cultivated land, built up area and water (Table 4.2.). Kowal (1966) describes the vegetation types in the region: "While the Cordillera Central is generally called the 'Pine Region', there are three important types of vegetation present aside from agricultural land: montane forest, pine forest and grassland"… Most of the areas in the Cordillera Central above an elevation of about 2000 meters are occupied by tropical montane forest (Richards 1952), a rainforest-like formation unique because of the special environmental conditions associated with high elevations… Between about 2000 m and about 1000 m pine forest and grassland dominate. The pine forest tends to dominate the upper portion of this range and the grassland the lower, with considerable interdigitation and alternation of communities in between. In some areas, the grassland may extend all the way up to the montane forest, and in others the pine forest may extend all the way down to the valley floor" (p. 394).

Table 5.2: Description of land use/land cover classes

Land Use/Land Cover	Description
Dense forest	Pine, montane or lowland wood forests characterized by a dense canopy
Open forest	Mostly pine; not as densely forested, with grassy patches in between trees; partly brushland
Grassland	Relatively large patches of grassy land; used for pasture in the past; others abandoned after a period of cultivation
Open area/cultivated land	Wide cultivation areas for temperate crops; at different stages. The first months of the year are dry season period, thus soil is generally dry. This class may include eroded areas.
Rice/cultivated land	Mostly irrigated lands; both wet and upland rice agriculture; used alternately with subsistence crops such as sweet potato, or drained and left to fallow. Upland rice areas are on fallow in the first months of the year
Built up area	Settlement and commercial areas, but also includes cultivated lands as households tend to locate their homes close to their farms
Water	Rivers and streams; may include irrigated rice lands

An accuracy assessment yielded an overall assessment and a kappa statistic (Table 5.3). The kappa statistics imply the percentage of agreement of the classification with the reference data, thus leaving a 21% chance of disagreement in 1990; 29% in 2002 and 24% in 2007 (see Annex 2 for complete results).

Table 5.3: Summary of results of accuracy assessment

Year	Overall Accuracy	Kappa statistic
1990	81.90	0.7889
2002	75.24	0.7111
2007	79.05	0.7556

5.3. Description of land use/land cover per year

5.3.1.1. Land use of Bakun in 1990

In 1990, the most dominant land use/land cover class was dense forest with concentrations from the northern to the west-central sections of the municipality. The mountainous northern village of Bagu was not covered by any logging concession and even to this day is not accessible by land transportation. At that time most households were still engaged in subsistence agriculture and forests were generally unutilized. Also, portions of dense forest still existed in the southeastern part close to the national road. . These are located in higher elevation areas where pine forests dominate so these must have been sections of second growth forests under logging concession.

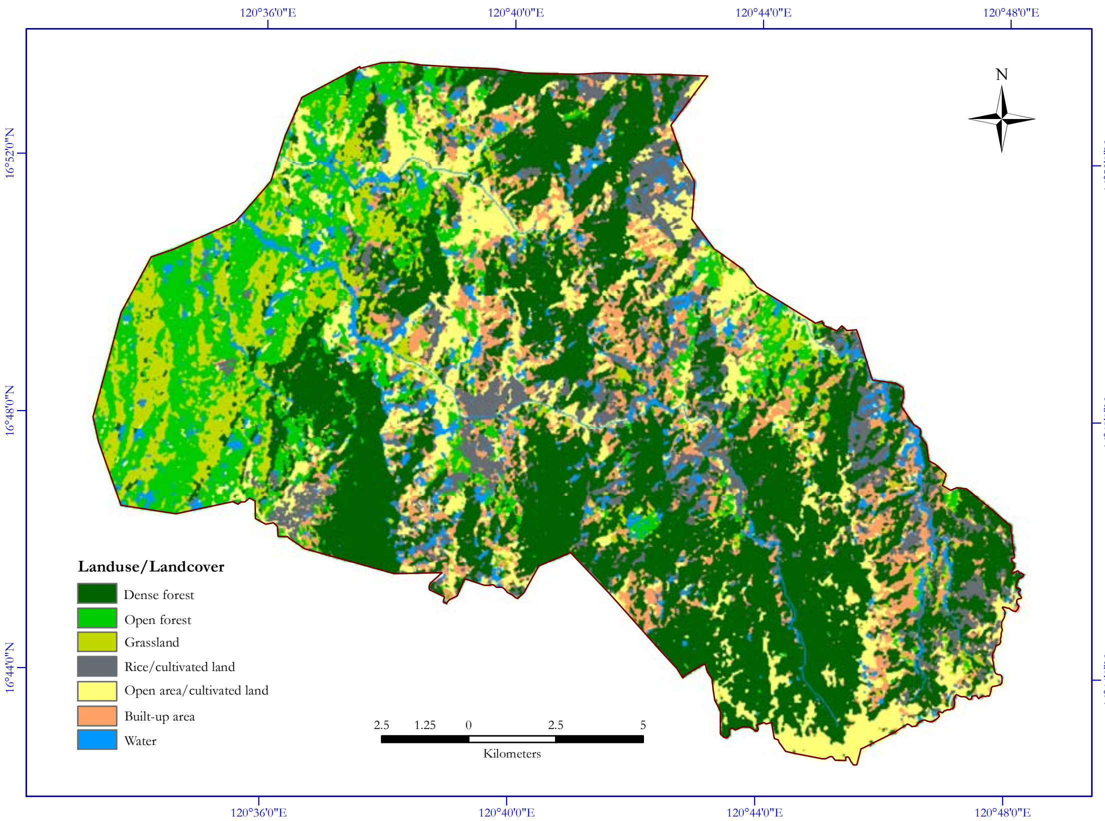

Figure 5.2: Land Use Map of Bakun (1990)

Table 5.4: Distribution per Land Use/Land Cover (1990)

Land Use/Land Cover	Area (in ha.)	%
Dense Forest	3,111.34	42.98
Pine/grassland	4,649.48	15.24
Open area/cultivated land	3,884.02	12.73
Grassland	2,902.25	9.51
Rice cultivated area	2,256.11	7.40
Built up area	2,250.66	7.38
Water	1,454.66	4.77
Total	**30,508.52**	**100.00**

Meanwhile, open forests occupied over 15% of the area, mostly in the western village of Kayapa, which has lowland vegetation and no pine forests. Kayapa was also not a concession area and can only be reached on foot from neighboring Poblacion or through another entry in the lowland province of Ilocos Sur. Grasslands, generally associated with pine, occupied close to 10%. These were used for pasture or opened up for permanent agriculture. Open/cultivated lands covering 13% of total land area were scattered across the municipality. The areas closest to the national road in the south were more extensively used than other locations. Rice/cultivated areas occupying over 7% were visible in all the barangays. This is expected as rice is a staple crop and production has been taking place twice a year in irrigated lands. Upland rice production areas, in the meantime, are either left to fallow or planted to other subsistence crops, like sweet potato, or a small volume of cash crops, for example, pepper. Many parts of built up areas are likely of mixed use, i.e. dwelling units and cultivated area. Traditionally huts or houses are surrounded by home gardens. Also, in occupied logged over areas, houses are built close to cultivated lands.

5.3.2. Land use in Bakun in 2002

The ban on logging was imposed in 1991 and the last TLA was terminated in 1998. In 2002, dense forests still dominated the landscape with almost 40% coverage; however, it is smaller from 12 years ago by as much as 1,120 hectares (Table 5.3). Change occurred mostly in the villages of Gambang and Ampusongan, both under logging concessions and also two of the major vegetable producing areas in the municipality. Open forests and grasslands decreased by 424 and 202 hectares, respectively, where grasslands in particular have become visible in the western and northern areas, indicating that there are land conversions taking place. The construction of the Bakun AC power plant outside the western border was completed during this time. A concrete bridge linking the foothills with the province of Ilocos Sur and a road reaching up to the village center in the west also opened up the area for vegetable production.

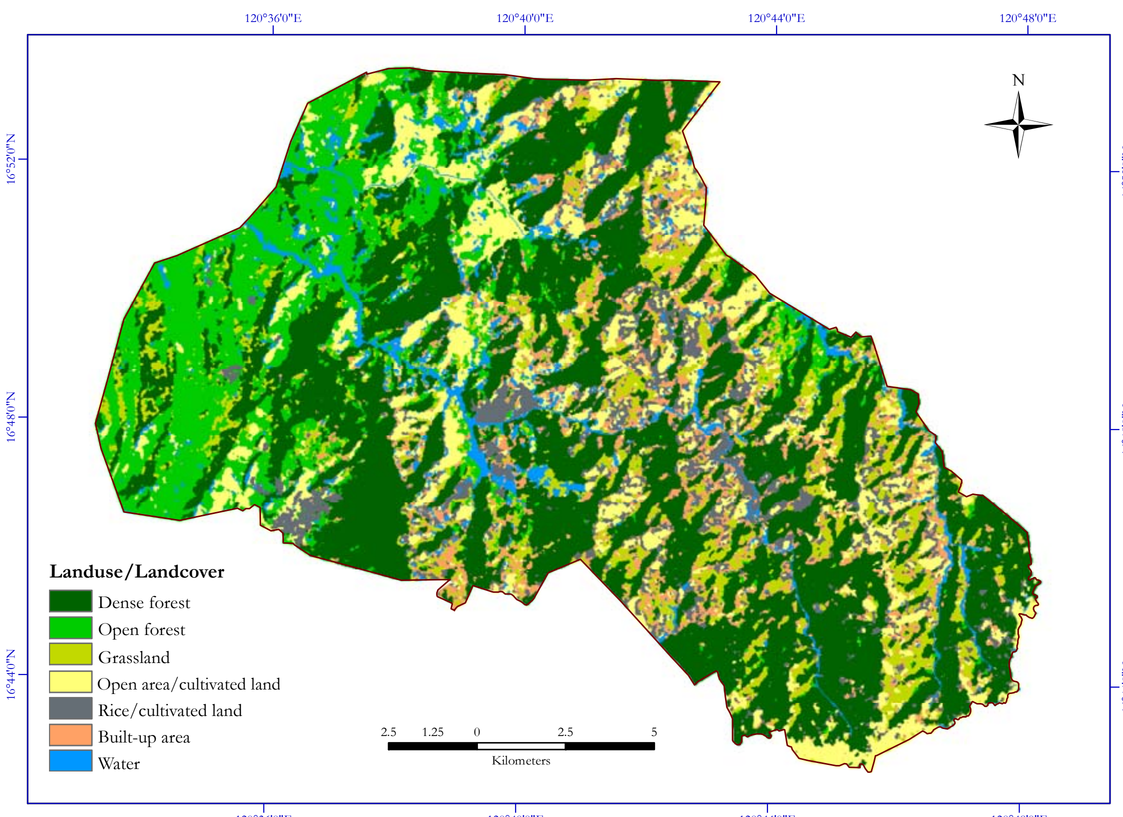

Figure 5.3: Land Use Map of Bakun (2002)

Meanwhile, there were cultivation areas all over the municipality and the total area increased by as much as 775 hectares since 1990. The built up areas and the water class increased but by small percentages from the previous year.

Table 5.5: Distribution per Land Use/Land Cover (2002)

Land Use/Land Cover	Area (in ha.)	%
Dense Forest	11,991.24	39.29
Pine/grassland	4,225.13	13.85
Open area/cultivated land	3,957.76	12.97
Grassland	2,699.67	8.85
Rice cultivated area	2,943.28	9.65
Built up area	3,025.31	9.91
Water	1,673.73	5.48
Total	**30,516.12**	**100.00**

5.3.3. Bakun in 2007

In 2007, the dense forest class remained to be the most significant land use/land cover in terms of area even if it decreased further from five years ago. Open forests and grassland areas have increased, mostly visible in the western village of Kayapa, where more households were engaging in vegetable production with the improved access to the lowland markets, and even directly to the capital of Manila. Built-up area hardly changed from five years ago.

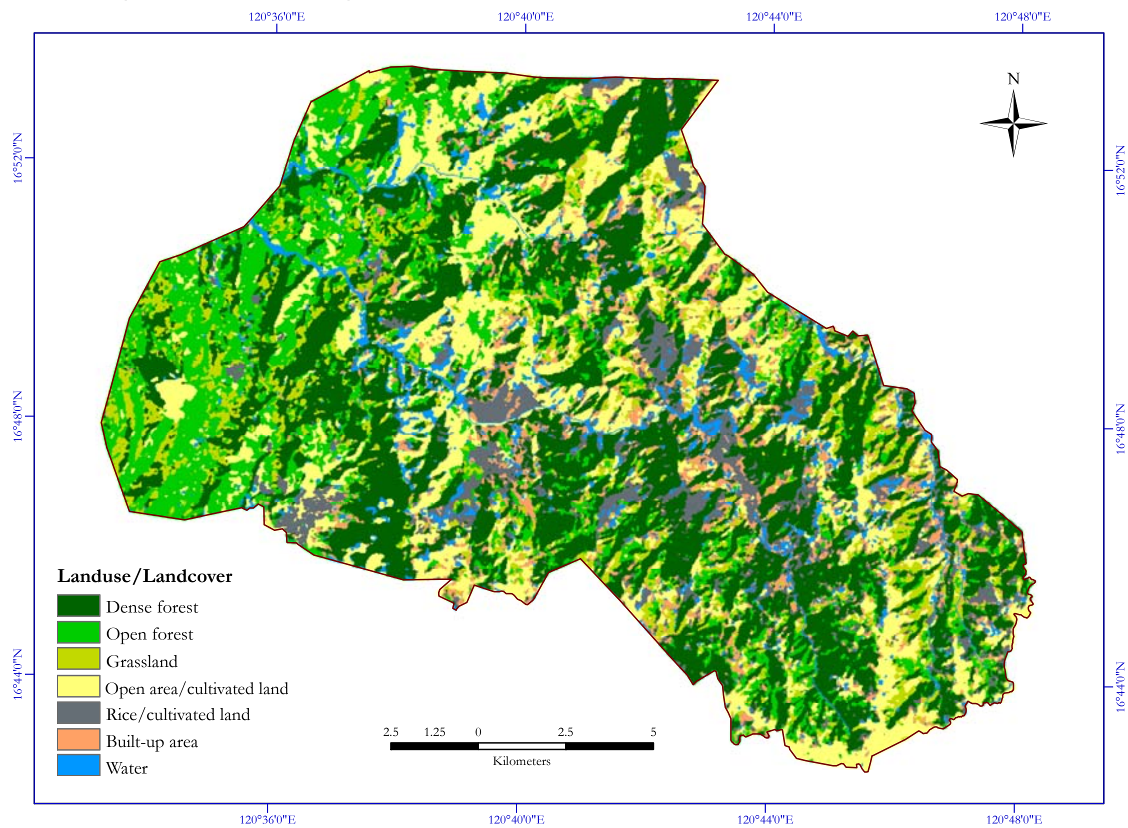

Figure 5.4: Land Use Map of Bakun (2007)

Table 5.6: Distribution per Land Use/Land Cover Class (2007)

Land use/Land cover	Area (in ha.)	%
Dense Forest	10,732.95	35.20
Pine/grassland	5,434.65	17.83
Open area/cultivated land	5,622.12	18.44
Grassland	2,802.87	9.19
Rice cultivated area	2,407.77	7.90
Built up area	1,984.59	6.51
Water	1,503.54	4.93
Total	30,488.49	100.00

In summary, over the 17-year period, the area of dense forest decreased significantly; while the area of open forest and cultivated lands increased. In the next section, the change in each class to other classes has been summarized and the result on the top 15 changes as far as area is concerned has been mapped.
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Table 5.7: Distribution of Land Use by Class and Area (1990, 2002, 2007)

Land use/Land cover	1990	%	2002	%	2007	%
Dense forest	13111.34	42.98	11991.24	39.29	10732.95	35.20
Open forest	4649.48	15.24	4225.13	13.85	5434.65	17.83
Grassland	2902.25	9.51	2699.67	8.85	2802.87	9.19
Open area/cultivated land	3884.02	12.73	3957.76	12.97	5622.12	18.44
Rice/cultivated area	2256.11	7.40	2943.28	9.65	2407.77	7.90
Built up area	2250.66	7.38	3025.31	9.91	1984.59	6.51
Water	1454.66	4.77	1673.73	5.48	1503.54	4.93
Total	**30508.52**	**100.00**	**30516.12**	**100.00**	**30488.49**	**100.00**

The summary table below shows the total area lost per class, percentage of change and average annual rate of change between periods. The dominant cover was forest classified as dense and open, and a growing cultivation area mostly of vegetables. The rate of change in the different classes showed that forests have been changing to some other class, but that not at the rate as in the 1977 to 1987 period. Note that together, dense and open forests were changing at an average of 2.8% in the last 17 years as opposed to 7.65% average during the logging period.

Table 5.8: Total Change per Class and Average Rate of Change

Land use/Land cover	1990-2002			2002-2007			1990-2007		
	Total area lost/ gained (in ha)	Total area lost/ gained (in %)	Yearly rate of loss/ gained (in %)	Total area lost/ gained (in ha)	Total area lost/ gained (in %)	Yearly rate of loss/ gained (in %)	Total area lost/ gained (in ha)	Total area lost/ gained (in %)	Yearly rate of loss/ gained (in %)
Dense forest	-1120.09	-8.54	-0.71	-1258.29	-10.49	-2.10	-2378.39	-18.14	-1.07
Open forest	-424.36	-9.13	-0.76	1209.52	28.63	5.73	785.17	16.89	0.99
Grassland	-202.58	-6.98	-0.58	103.20	3.82	0.76	-99.38	-3.42	-0.20
Open area/ cultivated land	73.74	1.90	0.16	1664.36	42.05	8.41	1738.10	44.75	2.63
Rice/cultivated area	687.18	30.46	2.54	-535.51	-18.19	-3.64	151.66	6.72	0.40
Built up area	774.64	34.42	2.87	-1040.72	-34.40	-6.88	-266.07	-11.82	-0.70
Water	219.07	15.06	1.25	-170.19	-10.17	-2.03	48.88	3.36	0.20

5.4. Spatial analysis of land use change

"It is virtually impossible to aggregate land use changes into a single, scalar indicator; (however), the rates or extent of land use changes can be represented in the form of a transition matrix of land uses, showing the transition between each pair of uses as extent or proportion of area per unit time" (FAO, 1997). The total area of change from one class to other classes was calculated by intersecting the land use maps. Using the Spatial Analysis Tools of ArcGIS 10, the three land use maps were turned into vector layers and intersected. The intersect map produced 100,255 cases showing different combinations of change in the three periods.

Comparing the results of the intersect map with the land use maps, the most unchanged classes were rice/cultivated lands everywhere in the municipality and the open/cultivated areas from the south towards the central part. Some dense forests remained unchanged, while grasslands contiguous to open forests and agricultural lands have been changed permanently.

The top 15 changes from one class to another having a total area of 399 hectares or higher are mapped (Table 4.8 shows the top 15 changes and Annex 3 contains the summary of all the changes). In each map, only the class and the changes within that class is shown. Of the seven classes, dense forest was changed the most over the 17-year period and to different uses. Figure 4.8 shows that many portions of dense forests have become open forest, indicating a thinning of the forest cover, either due to clearing within dense forests for farming or logging. These incursions are taking place everywhere, but quite substantially in the south close to the national road, as well as in Poblacion, Sinacbat and Kayapa which are host communities to the mini-hydro plants. Kayapa is currently receiving substantial financial contributions and other benefits from the mini-hydro company, including road improvements. Most of the lands are privately owned as woodlots and owners are invoking their right over those lands and convert to other uses.

Table 5.9: Transition Matrix on the Top 15 Changes

Change from one class to another class	Total area (ha)
Dense forest to open forest	1,523
Dense forest to grassland	798
Dense forest to rice/cultivated area	778
Dense forest to built-up area	723
Dense area to cultivated land	624
Open forest to grassland	610
Open forest to open/cultivated land	584
Open forest to dense forest	570
Grassland to open/cultivated land	604
Grassland to open forest	555
Grassland to dense forest	509
Built-up area to open/cultivated land	584
Rice to open/cultivated land	480
Water to open/cultivated land	450
Built-up area to dense forest	399

Dense forests also changed to grassland, to cultivated land and to built-up area. It can be assumed that all these changes are to cultivated lands. The change to grassland is likely a prelude to further improvement for cultivation, and some areas that are classified as built up as mentioned earlier can be cultivation areas as well because people tend to build their homes close to their farms. Changes in open forests have mostly taken place in the western side where the most important transformation is to grassland, again likely a land use leading towards further improvement for farming.

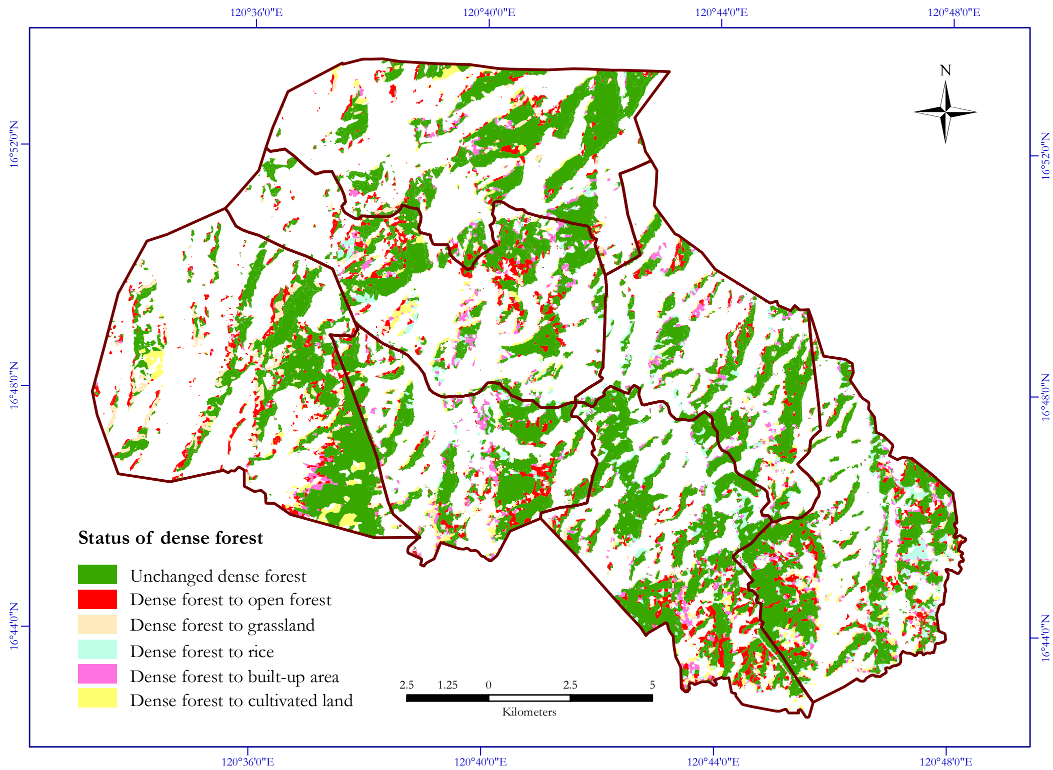


Figure 5.5: Conversion of Dense Forest to Other Classes

There is a change from open forest to dense, likely in areas that are relatively inaccessible or reforested areas in private woodlots, communal lands or delineated community "watersheds" areas. These watershed areas are communally protected by the local government and the community, primarily to ensure a steady supply of potable water, maintain river stream flow, secondarily, and where strict enforcement of rules are generally observed and where penalties are imposed on people caught illegally cutting trees, burning or causing any damage. Meanwhile, in the lowland village of Kayapa in the west, the cropping calendar is different from the upstream villages and what may have been interpreted as grassland are agricultural lands newly planted to vegetables.

The construction of a road that reaches the village center and the construction of a bridge that links the foothill communities with the lowland markets provide the incentive to convert forests to farm lands, in both privately owned and communal areas. As claimed by an informant, bulldozers have been hired to clear private lands for agriculture. Rice lands were also converted for commercial vegetable production and households buy rice in the lowland markets. An informant illustrated the change in practices in the area. Where before people talked about the quality of their newly harvested staple crops like sweet potato; now they talk about market prices of rice and other agricultural commodities.

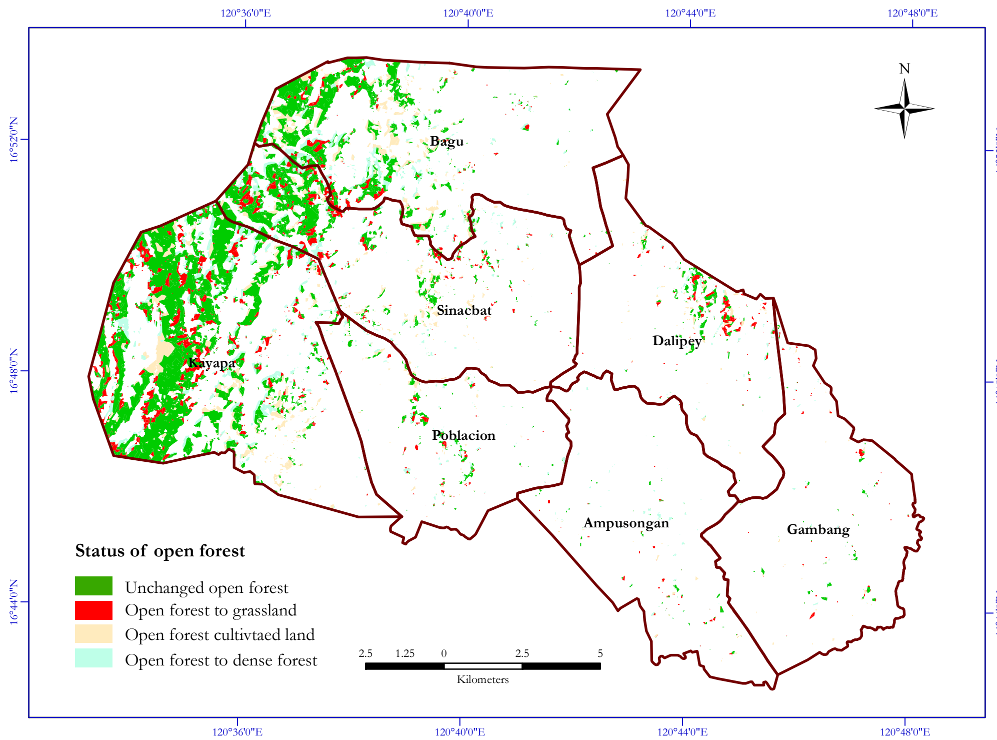


Figure 5.6: Conversion of Open Forest to Other Classes

Grasslands were also transformed to cultivation area across the study area, but most visible in the south and southeast villages with the longest history of vegetable production. Grasslands used to be pasture areas, but cattle raising is no longer an important economic activity, thus the permanent conversion to agriculture, or to dense and open forests. These are probably places where the terrain may be too harsh or too labor-intensive to maintain as cultivation areas or part of protected community watershed areas.

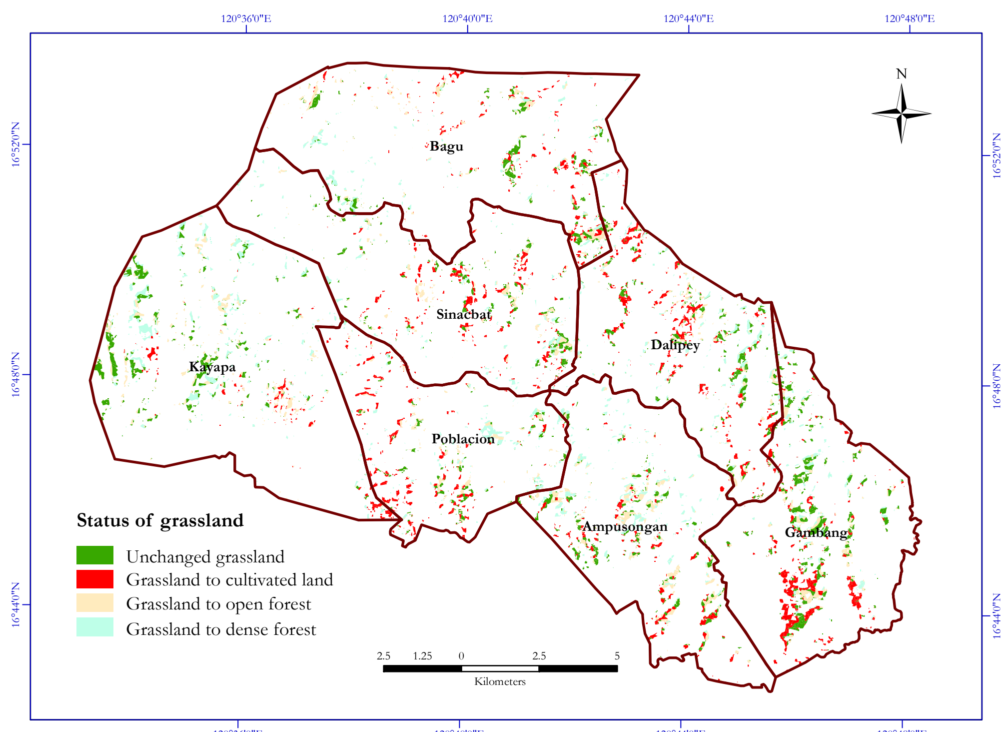


Figure 5.7: Conversion of Grassland to Other Classes

5.5. Spatial analysis of roads and land use effects

To assess the impact of infrastructure on the change in land use, some spatial analysis was undertaken. A buffer of 500 meters was created on all roads excluding paved footpaths. The differences in area between 1990 and 2007 and the differences in rates of change between the area within the buffer and the area outside the buffer were compared, the premise being that changes will not be as much as in areas within an access road. Results showed that there is more land use change within the 500 meter buffer than outside it.

Table 5.10: Distribution of Area per Land Use within and outside a 500-m Road Buffer (1990 and 2007)

	Area (within 500 m)			**Area (outside 500 m)**		
Landuse	**1990**	**2007**	**Diff. (ha)**	**1990**	**2007**	**Diff. (ha)**
Dense forest	5,682.50	4,197.96	-1,484.54	7,620.85	6,691.14	-929.71
Open forest	684.81	1,461.96	777.15	3,981.97	4,020.03	38.06
Open area/cultivated land	1,337.69	2,232.00	-319.73	2,588.15	3,460.41	214.27
Grassland	1,378.31	1,058.58	894.31	1,573.49	1,787.76	872.26
Rice/cultivated area	1,202.37	1,293.57	91.20	1,098.08	1,172.97	74.89
Built up area	1,300.82	1,141.65	-159.17	991.11	879.30	-111.81
Water	413.92	613.53	199.61	1,064.29	910.71	-153.58

The rate of change of the open forest class increased most significantly. This is due partly to reforestation efforts carried out in the early 1980s when the logging companies led in road stabilization efforts by planting trees right along the roads; the location of some delineated protected areas within roads, and also also partly due to the decrease in the area of dense forests within the buffer. On the contrary, there was hardly any change in the open forest outside the buffer. Cultivated lands within the 500 meter buffer increased twice that outside the buffer; correspondingly, dense forest and grassland areas decreased twice more within the buffer than outside.

The much lower rate of change outside the buffer indicates less interest to develop agricultural lands where additional costs on hauling will be incurred. The rice/cultivated lands had almost similar rates of change within and outside the buffer, a likely situation considering that most of the rice lands were there even before the roads were built.

Table 5.11: Rates of Change Within and Outside a 500-m Road Buffer (1990 and 2007)

Land use/Land cover	**Rate of change within the 500-meter buffer (%)**	**Rate of change outside the 500-meter buffer (%)**
Dense forest	-26.12	-12.20
Open forest	113.48	0.96
Open area/cultivated land	66.85	33.70
Grassland	-23.20	13.62
Rice/cultivated area	7.58	6.82
Built up area	-12.24	-11.28
Water	48.22	-14.43

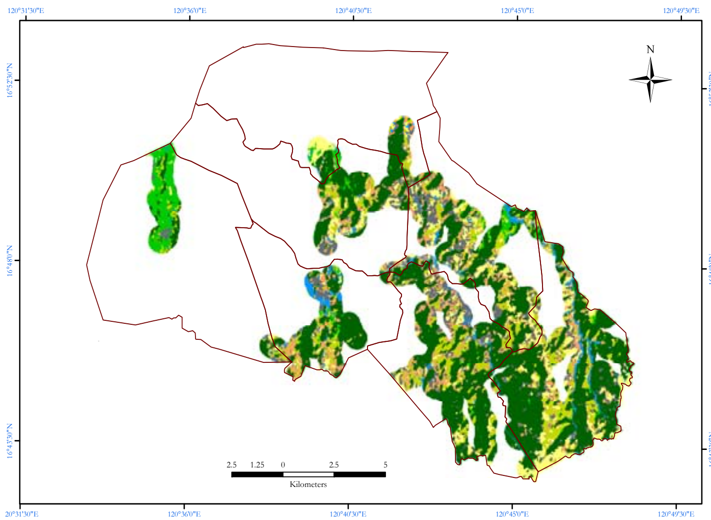


Figure 5.8: Land Use Within a 500-meter Buffer (1990)

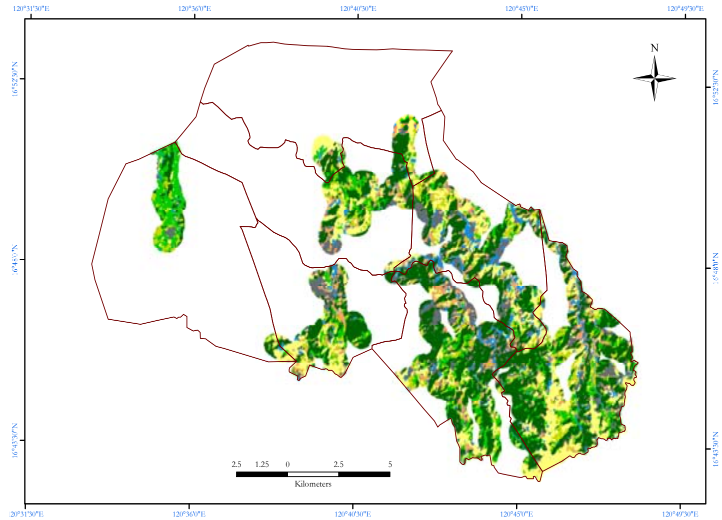


Figure 5.9: Land Use Within a 500-meter Buffer (2007)

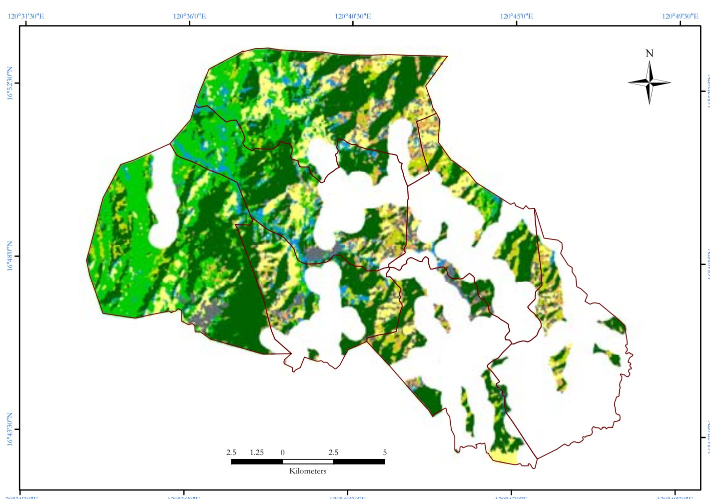


Figure 5.10: Land Use Outside a 500-meter Buffer (1990)

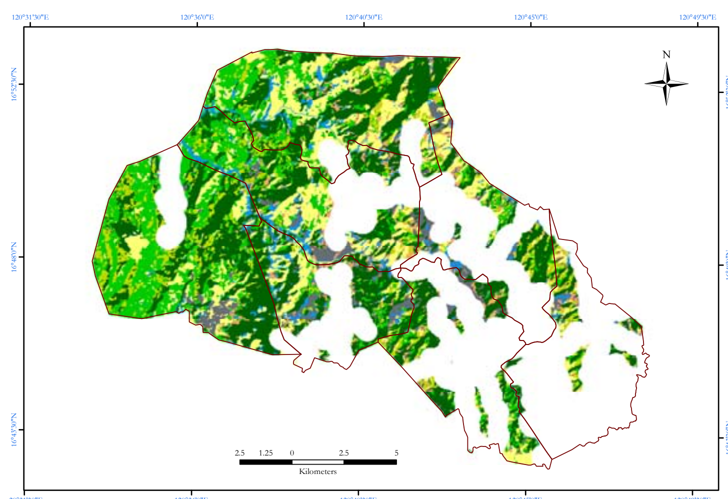
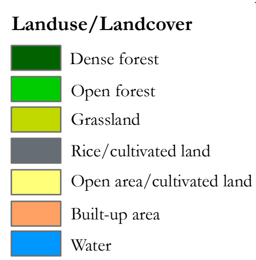


Figure 5.11: Land Use Outside a 500-meter Buffer (2007)



5.6. Summary

A calculation of average annual change between periods (Long *et al.* 2007) shows that dense forest, grassland and built up area decreased continuously over the 17-year period, while the total cultivated lands increased along with open forests. The average annual decrease in dense forest was higher in the second period, i.e. 2002 to 2007. Open forests have increased, more so in the second period; a trend also seen for grasslands and built up areas. Meanwhile, cultivated lands progressively increased over the years at an average annual rate of 1.38%.

Within a period of 30 years, significant changes in land use have taken place in the study area. In 1977, the dominant cover class was forest, mostly pine in the higher elevations and lowland hardwoods in the village in the west closest to the coastal province. Roughly 78% of the municipality at the time was under logging concessions, such that by 1987, the area was almost totally logged over and brushlands predominated. The results of the land use change analysis on 1990, 2002 and 2007 showed that forest, in this case dense, open, and grassland, dominated the landscape. However, within the 17-year period, dense forest and grassland areas decreased, with commensurate increase in open forest and cultivation areas.

An analysis on changes from one class to another class showed that most affected are dense forests, open forests and grasslands. Dense forests have degraded to open forests, grasslands or converted to cultivated lands. Open forests increased in size mostly due to a reduction in the area of dense forests, but in many places such as in the west, grasslands and cultivation areas have taken over. Still, there were areas that transformed to dense forests, implying the effect of reforestation and non-use over the years. Grasslands no longer used for pasture have become cultivation areas. Many built up areas likely containing a fairly significant amount of cultivation areas in previous years transformed to cultivation areas at the end of the seventeen-year period.

The rate of change in cultivated areas was twice within the buffer, implying that more lands were converted along the roads more than in places farther away from it. Grasslands decreased twice as much as well within the buffer than outside of it. This means that grasslands have been used for other purposes, either reforested or for cultivation. The rate of change in dense forests was also twice within the buffer, attributed to conversion of lands for agriculture. In the absence of roads, therefore, there is less incentive to convert current use to agriculture. Meanwhile, the rate of change in the water class was high compared to a reduction outside the buffer. Since the classification also includes irrigated lands, it is possible that the decrease is due to the abandonment of rice lands in favor of other areas for cultivation close to roads. No new rice lands were likely opened in areas within the buffer knowing that vegetable farming is now the preferred farming activity, so the increase can be attributed partly to an improved surface flow in rivers brought about by an improvement in forest cover along roads. More analysis, however, is needed to establish such a correlation.

An analysis on the effect of roads on land use change showed clear differences, supporting the argument that road extension and improvement cause a change in land use. The changes within a 500 meter buffer on roads and outside it were compared. Open forests increased significantly within the buffer, a likely effect of road stabilization efforts over the years and the improvement in the forest cover in protected areas close to the roads. The change, however, is also an effect of the degradation of dense forests with the opening of new cultivation areas. In contrast, there was hardly any change in open forests outside the buffer. One explanation is the absence of intervention like reforestation in these areas. Another factor is terrain, where the steepest and most rugged areas had mostly been covered by grasses since people can remember.

6. LINKING THE DRIVERS OF LAND USE CHANGE AND SPATIAL ANALYSIS

This chapter provides an analysis of the results of the study, i.e. from the narrative of Bakun's development that also explains the drivers of change and the results of spatial analysis. After discussing the causes and underlying factors of land use change, the most influential factors are identified. This discussion will expose the reality that various drivers and many underlying factors exert varied influences on land use. The dilemma in land use posed by Foley et al. (2005) is revealed in this case study, i.e. that "(o)n one hand, many land-use practices are absolutely essential for humanity, because they provide critical natural resources and ecosystem services, such as food, fiber, shelter, and freshwater. On the other hand, some forms of land use are degrading the ecosystems and services upon which we depend…" (p. 570)

The economic and spatial transformations in the study area are due to interrelated socio-economic, cultural and policy factors. To understand land use change, a simple linear diagram (recall Figure 3.2) modeled the interconnectedness of the different factors and drivers. It showed that there are direct drivers as well as underlying factors that influence the drivers. A historical narration and an investigation of contemporary events revealed that a more complex pattern of spatial and temporal causative arrangements and feedback relationships exists (see Figure 6.1). In reality, direct drivers can cause land use change at the same time or at different periods in time; their intensity also differing and effects on local development sometimes unpredictable. Also, underlying factors independently or together and in different combinations affect a direct cause of land use change. The intensity of effects also differs and can be negative, positive or non-existent. In a nutshell, the study area transformed from a subsistence economy to a cash economy. It also transformed spatially, its land use having changed depending on the events that have occurred through time.

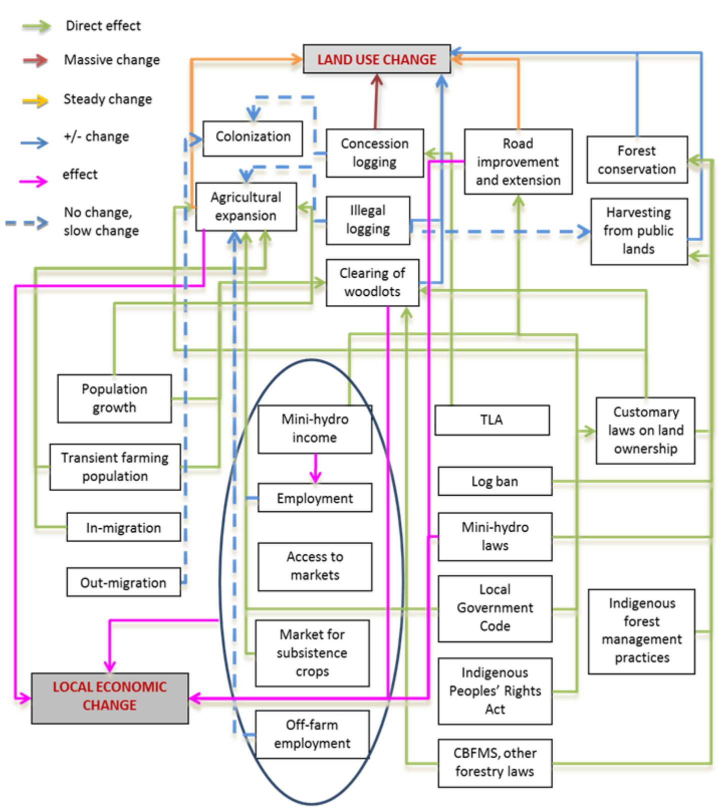


Figure 6.1: Diagram of Causes of Land Use Change in Bakun

6.1. Proximate causes of land use change in Bakun

The direct causes of land use change are wood extraction, agricultural expansion and road improvement and extension. Commercial logging that lasted at least 50 years permanently changed the land use and land cover in the study area. At the end of the logging period in the 1990s, most of the area's primary forests have been replaced by secondary pine forests or converted to agricultural uses. The implementation of logging was governed and facilitated by American colonial laws that awarded timber license agreements on Bakun lands that were traditionally held by indigenous peoples. Non-compliance with the terms on reforestation on concession lands in the early years led to unmanaged forest clearing and the eventual permanent conversion of lands to agriculture. Compliance in later years led to some restoration of forest cover at the end of the TLA period in 1998. While others were reclaimed right away, other areas led to illegal activities despite a ban on logging. As pointed out by Guiang (2001), "the cancellation, non-renewal, and suspension of TLAs increased open access and contributed to illegal logging and cutting, and have greatly added to the loss of forest cover (p.18)."

Community response to logging differed, but in general caused further change in land use, mostly from forest use to agriculture use. People that used to own lands by virtue of customary law were forced to comply with national laws on titling to ensure their ownership. To make this happen, woodlots were cleared and declared as agricultural lands.

Agricultural expansion is another direct cause of land use change, first occurring along roadsides then to logged-over areas abandoned by loggers in the early years; and eventually into reforested lands at the end of commercial logging. In-migration into forests previously sparsely occupied by indigenous groups is triggered by government decisions authorizing extractive industries, such as logging where undoubtedly, "spontaneous" colonization or occupation in opened up forests takes place (Lambin *et al.* 2001). As observed in the spatial analysis, dense forests gradually degraded since the 1990s, either through direct change to cultivation land or downgrading to open forest. The increase in open forests as seen in the spatial analysis is an increase in the patchiness of forests, indicating that some other use within former dense areas has taken place. Grasslands were also converted to agriculture and former rice lands and swidden farms became permanent vegetable production areas.

The change in forest use is also influenced by the improvement and extension of roads. Roads were opened in the 1970s but were unmaintained, then restored mostly from the 1990s. At present, there are different types of roads that give people access to their farms and to the market. The transformation of land is notably different within roads than in less accessible areas. As proven in the spatial analysis, there was more conversion of lands to cultivation and more disturbances to dense forests within 500 meters of roads. There was less conversion of forest lands further away from roads. This situation supports the assertion that the extent and the location of land-use conversions are influenced to a large extent by the ability of people to reach desired locations, such as a market or a forest (Geist & Lambin, 2002; T. Lakshmanan & Chatterjee, 2005; Olsson, 2009; Verburg & Veldkamp, 2004). Accessed forests are converted for farm use than any other use. Agroforestry has been an option but remained small-scale and did not really prosper as a main livelihood source. This is due in part to failed agroforestry attempts in the past, but also because of the immediate need for cash returns that vegetable production is able to provide. So, with no income from maintaining a forest use and limited livelihood opportunities, an improved access to both land and market makes a change to agriculture use a viable option. Environmental conservation is a fourth direct cause of land use change, but in this case, it implies a no-change, or a slow change, as opposed to the influences of the other direct causes.

6.2. Underlying factors

Factors underpinning the direct causes of land use change are demographic, economic, policy and cultural factors (Geist & Lambin, 2002). In Bakun, demographic influences are natural population growth and a transient population who engage in share cropping arrangements or rent lands from other farmers. Their use of existing agricultural lands pushes the opening of new private lands by local farmers. These demographic factors generally affect agricultural expansion. On the other hand, there is out-migration, by professionals and non-professionals alike in search of other sources of livelihood elsewhere in the municipality. This movement has no effect on any of the direct drivers.

Economic factors are government income and short term and long term employment for households from the mini-hydro companies, access to markets, commercialization of subsistence crops and off-farm employment. As observed on 152 case studies on drivers of deforestation, 88% of the cases were driven by multifactor terms of causation and that economic factors were most prevalent as seen to be present in 81% of the case studies (Geist & Lambin, 2002). In the case study, these underlying factors affect the direct causes differently.

Local government income is an underlying factor of road extension and rehabilitation. The sustained development of infrastructure in the area is due to a large extent by the local government's improved fiscal autonomy and capacity. Regular income from the internal revenue allotment limits the amount that can be used for development projects, such as road construction and improvement. However, resources accessed from national and provincial agencies, as well as the additional regular income derived by the local government from the mini-hydro companies and the latter's voluntary contributions have accelerated infrastructure improvements in Bakun. Almost all villages are now linked to the town center and in general have improved access to the major outlets for agricultural products.

The Local Government Code gives the local government unit the authority to respond to what people want, among them, roads improvement, in order for them to engage in agriculture and also have the opportunity to participate in other economic enterprises, thereby hopefully improving their lives. Their behavior, however, will impact on the land. In order to increase income, they can either intensify the use of their existing farms, utilize their current swidden or rice farms to vegetable production, or with roads, can actually open up new forested lands to agriculture. They can do this because of their vested rights on their woodlots by virtue of the IPRA and the terms of the CADT. Treated as privately- owned lands, woodlot owners have the right to convert their lands to other uses. Should they do this, their objectives would be contrary to the local government unit's objective of maintaining forests, since it is interested in making sure sufficient hydrologic resources are supplied for the mini-hydro power plants, which are contributing substantially to government coffers. The government needs to maintain this, in order to continue receiving the contributions and in turn provide development projects to keep its constituents happy. It is therefore faced with a dilemma, that of providing the needs of its constituents but also making sure the forests stay well-stocked.

Through special arrangements and based on the provisions of energy laws, the local government receives taxes, donations and other forms of support from the use of hydrologic resources in the area. This additional income has improved service delivery and also funded infrastructure projects that improve access to lands and markets. A spatial analysis on the effect of roads on land use showed, for example, that more land conversion for agriculture and a degradation of dense forests and grasslands along roads. The community is behaving as though their activities will not have any future effects on the quality of ecosystem services that their watershed provides. The local government is focused on improving roads, but not looking at people's activities as an effect of their improved access.

A growing market for cash crops greatly influences agricultural expansion. Production from the early years improved largely due to Spanish, American, Chinese and Japanese entrepreneurs who provided the technology and the market. Commercial agriculture intensified and production areas expanded as demand from a growing population in urban areas is increasing. A market for subsistence crops also influences agricultural expansion some extent. In general, subsistence crops are planted on home gardens or existing swidden plots. Where before, items like corn, peanuts, sweet potato, cassava and fruit crops were meant for household consumption, today a local market for these provide some households a cash source. The spatial analysis showed a progressive increase in agricultural lands, a steady decline in dense forests and grasslands.

Cultural factors also influence the direct causes, mainly agricultural expansion and wood extraction. In the past, selective logging was practiced because there were less people and in general, there was no market for wood. At the end of logging, most people with woodlots were able to repossess their clan-owned woodlots. These are privately owned and managed resources and in principle, an owner can decide on how to use his land. These yielded two kinds of responses – maintenance of woodlots as forest and conversion to agriculture.

Selective logging as a traditional conservation practice continues to be advocated but no longer widely observed. It must have been so much easier to impose selective logging then when economic life was generally subsistence; the extent of commerce was barter and land was more than enough for a small self-governing population whose need for lumber was to build homes big enough to accommodate the bare essentials of rural living and whose main goal was to have enough food in order not to go hungry during the rainy season. Conditions are different now for such a principle to be easily followed. There are still limited income sources; there is a need for cash, there is a market for vegetable crops, and there is a greater need for wood with households building bigger houses or building second homes in the urban area. With construction materials elsewhere being costly, people opt to comply with current local ordinances and harvest from their forests. This customary practice therefore influences both wood extraction and conservation.

6.2.1. Underlying factors of conservation

Meanwhile, there are other factors that influence conservation, among them a ban on logging and reforestation. The ban on logging prevented further extraction and slowed the conversion of lands to agriculture. Similarly, reforestation activities may have had an aggregate positive effect. Over the years, the logging company, the mini-hydro companies, the people themselves and the government initiated reforestation. The specific places that these occurred were not mapped in this study, but in most cases they have taken place in communal forests or delineated community watershed areas. Further, other factors like livelihood engagement in non-farm activities and outmigration influence land use and the effect is opposite that of agricultural expansion, wood extraction and roads extension. The spatial analysis shows, for example, that there have been changes from the other classes to dense forests indicating a possible influence of conservation on land use.

6.3. Policy as an important underlying factor of land use change

The historical narration on resource use in the area revealed the significant influence of policy on land use change (see Table 6.1). In the beginning, indigenous law imposed selective logging with the objective of sustained utilization and resource conservation. Coupled with a relatively small population, this resulted in insignificant changes in land use. The superimposition of a national law that allowed the extraction of timber, on the other hand, saw the permanent conversion of lands from forest to other uses. The issuance of Timber License Agreements in the area by the national government deprived the community of their resources and livelihoods and usurped their rights to their forest resources. A national ban on logging was later imposed to conserve watershed resources. Meanwhile, a number of energy laws on mini-hydroelectric power generation, the decentralization law and the Indigenous People's Rights Act were enacted and implemented and the national forestry law was reformulated espousing greater community participation (see Venn diagram). It is within this continuum of policies that land use change in Bakun can be viewed.

The present structure implies a more sustainable direction for Bakun, considering for example, that unlike in the past where forest extraction was for the benefit of the national government, a PES-like scheme (Pattanayak, Wunder, & Ferraro, 2010) now exists in which the community through the local government receives benefits for the use of its hydrologic resources from mini-hydro companies, with the assumption that the former will ensure the continued provision of the ecosystem service through forest conservation. Indigenous rights are also recognized, reforestation efforts more community-based, and economic activities essentially supported through the improvement of transport infrastructure. Numerous issues plague the relationships of actors, such as different interpretations on ownership rights and resource use, implementation tensions, priorities of the local government versus household economic goals, selective implementation of provisions of mini-hydro power generation laws, etc. Resolving these is a challenge of governance that requires integrating scales and levels, sectors and aspects and consideration of uncertainties and openness to continuous learning (Bressers & Kuks, 2003). However, this confluence has, to a certain degree, achieved the openness "to create new, or unfamiliar, modes of formal and informal relationship among the social levels involved that Bressers and Rosenbaum (2003) suggest in the pursuit of sustainable development.

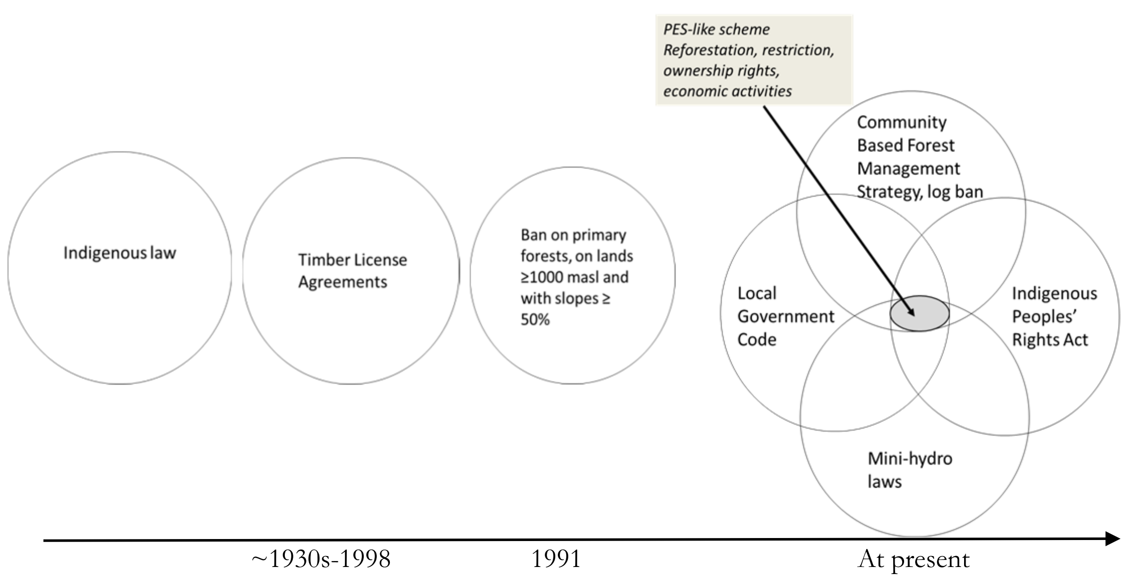


Figure 6.2: Summary of Policies over the Years

7. CONCLUSIONS AND RECOMMENDATIONS

This case study was undertaken in Bakun, an upland farming community in the northern Philippines, with the goal of discovering the main causes of land use change and analyzing their effects on economic development and spatial transformations. This chapter provides a summary of conclusions, a critique of the methodology and some recommendations for future research.

7.1. Conclusions

a. The study area transformed from a subsistence economy with a small population that evolved its indigenous systems of resource use to a growing population with a relatively robust local agricultural economy. The most important direct causes of land use change over the years were industrial timber extraction, agricultural expansion, the improvement and extension of roads and conservation. These direct factors influenced each other, as well, such as the permanent conversion of lands to agriculture as a result of commercial logging.

b. Underpinning these direct causes differently were (1) demographic factors, namely a growing population, a transient farming population and the outmigration of locals for employment elsewhere; (2) economic factors primarily market access, local government income from mini-hydro power generation, employment and off-farm livelihoods; (3) national policies implemented in the area over the years, and (4) cultural factors, primarily the recognition of customary rights to land and indigenous forest management practices.

c. A land use/land cover change analysis provided proof of spatial transformations. The latter part of the logging period revealed a change in land cover over a 10-year period, from pine to brushland. From 1990 to 2007, a decreasing dense forest area resulted to an increase in the area of open forests and agricultural lands. Further spatial analysis showed the transformation of dense forest to all other uses, most significantly to open forest that indicates a disturbance of the dense forest. Meanwhile, the effect of conservation must be responsible for the increase in forest and to a certain extent, open forests. Most of the other land uses had areas transforming to cultivated lands, supporting the qualitative assessment made. Meanwhile, change within roads were noticeably greater than in areas farther away,

d. While all the factors and drivers contribute in different ways to land use change, policies that underlie direct causes were found to be the most influential factor in land use change.

Historically, post-war timber license agreements facilitated the harvesting of trees, permanently altering the forest cover and triggering the expansion of agricultural lands. The imposition of a ban on logging later on to revive and protect remaining forests started a new direction in environmental conservation and slowed the change from forest use to other uses. At present, another resource is being exploited, but this time, the assurance of sustained provision is through payments and the benefit sharing arrangement becomes beneficial to the local government and to the citizens indirectly through the improvement of services and infrastructure, that in turn facilitate the access of citizens to both lands and market. This arrangement is playing out within a new set of state policies that are in place, not only on alternative energy generation, but also on democraticized participation, recognition of indigenous rights and the promotion of indigenous knowledge, systems and practices. This is further supported by a change in national forestry policy that espouses a community-based approach. All these policies seem to contribute to a more sustainable future, but the convergence of laws poses a governance challenge on the local government which is central in making sure that economic and environmental conservation objectives are met.

7.2. A critique on methodology

This study treated "land cover" and "land use" as synonymous, even if these two concepts are fundamentally different. The classes created were deemed appropriate for the intention of the study, which was to detect broad patterns of change and inasmuch as the unit of analysis was the community and not individual households or specific land uses. Secondly, forests in the study area have actual uses, such as woodlots or reforestation areas, but these were not delineated systematically during the fieldwork, thus the limitation in creating specific land use classes. What the analysis achieved, nonetheless, is a description of change over time, providing quantitative results as evidence to support the identified drivers in the narrative. The analysis of change from one class to other classes quantified the rates of change and the maps provided the actual location of changes. Also, the comparative analysis on the effects of roads on land use change within and outside a given buffer provided evidence on the assertion that roads trigger land use change.

7.3. Recommendations

Apart from the land use/land cover change analysis, this study was unable to provide quantitative measures to assess the contribution of each identified cause of land use change. Investigating each in greater detail and quantitatively may yield a different set of explanations on the same issue.

Meanwhile, in using remotely sensed data for land use/land cover change detection, higher resolution data should be preferred especially if specific land use changes are being detected. Otherwise, ways to increase accuracy have to be imposed. This can be by collecting more ground control points, trying different classification methods and comparing results, and validating results on the ground. In choosing images, it is also desirable to use data close to or on the same season as the research period to increase accuracy.

The current policy environment in the study area is an interesting backdrop to study further governance issues and sustainable development. The interactions of the indigenous peoples, their traditional leaders and the local government, the different priorities of actors and how these are negotiated, the sharing of benefits from the exploitation of ecosystem services, how the oftentimes conflicting economic and conservation objectives are negotiated, are but a few possible entry points to study scales and levels, sectors and aspects and time and learning, three aspects of sustainable development that have to be integrated, as suggested by Bressers and Rosenbaum (2003).

LIST OF REFERENCES

Abdullah, S., & Hezri, A. (2008). From forest landscape to agricultural landscape in the developing tropical Country of Malaysia: Pattern, process, and their significance on policy. *Environmental Management, 42*, 907-917.

Aspinall, R. (2008). Basic and applied land use science. In R. Aspinall & M. Hill (Eds.), *Land Use Change Science and Policy and Management*. Boca Raton: Taylor & Francis Group.

Bakun Ancestral Domain Sustainable Development and Protection Plan (ADSDPP), Bakun, Benguet. (2004).

Bakun Integrated Watershed Development and Management Plan (2007-2017). (2007). Bakun, Benguet.

Blom, B., Sunderland, T., & Murdiyarso, D. (2010). Getting REDD to work locally: lessons learned from integrated conservation and development projects. *Environmental Science & Policy, 13*(2), 164-172.

Boquiren, R. (Ed.). (2004). *Rewards for Environmental Services in the Philippines Uplands: Constraints and Opportunities for Institutional Reform*. Bogor, Indonesia: World Agroforestry Center (ICRAF).

Brandt, J. S., & Townsend, P. A. (2006). Land use - land cover conversion, regeneration and degradation in the high elevation Bolivian Andes. *Landscape Ecology, 21*(4), 607-623.

Bressers, H. (2004). Implementing sustainable development: How to know what works, where, when and how. In W. M. Lafferty (Ed.), *Governance for sustainable development: The challenge of adapting form to function* (pp. 284-318). Cheltenham: Edward Elgar Publishing.

Bressers, H., & Kuks, S. (2003). What does 'governance' mean? From conception to elaboration. In H. Bressers & W. Rosenbaum (Eds.), *Achieving sustainable development: The challenge of governance across social scales*. Westport, Connecticut, London: Praeger.

Bressers, H., & Rosenbaum, W. (2003). Social scales, sustainability and governance: An introduction. In H. Bressers & W. Rosenbaum (Eds.), *Achieving sustainable development, the challenge of governance across social scales*. London Praeger.

The Brundtland Report, Our Common Future (1987).

Cadiogan, A., & Bangaan, C. (2007). Sharing Benefits with Indigenous Peoples: The Hydro-Electric Power Plants in Bakun, Benguet, Philippines. Tebtebba Policy Research Center.

Chowdhury, R. R. (2006). Landscape change in the Calakmul Biosphere Reserve, Mexico: Modeling the driving forces of smallholder deforestation in land parcels. *Applied Geography, 26*(2), 129-152.

Colongon, A., Tapang, B., Cayabyab-Orticio, N., & Follosco, A. (2004). Community Response to Interventions in Forest Management and Upland Agriculture. Cordillera Studies Center, University of the Philippines Baguio.

Cruz, R. V., Suminguit, V., & Folledo, A. (2005). Assessment of the Hydrologic Functions of Bakun Watershed. World Agroforestry Center.

de Bie, C. A. J. M. (2002). *Yield gap studies through comparative performance evaluation.* Paper presented at the ISPRS Commission VII International Symposium : Resource and environmental monitoring, Hyderabad, India.

Engel, S., Pagiola, S., & Wunder, S. (2008). Designing payments for environmental services in theory and practice: An overview of the issues. [Article]. *Ecological Economics, 65*(4), 663-674.

FAO. (1995). *Forest Resources Assessment 1990* Food and Agricultural Organization of the United Nations.

FAO. (1997). *Land quality indicators and their use in sustainable agriculture and rural development*: Food and Agricultural Organization of the United Nations.

FAO. (2001). *Forest out of bounds: Impacts and effectiveness of logging bans in natural forests in Asia-Pacific*: Food and Agricultural Organization of the United Nations.

FMB-DENR. (2008). Philippine Forestry Statistics Retrieved January 31, 2011, from Forest Management Bureau - Department of Environment and Natural Resources. In http://forestry.denr.gov.ph/stat2008.htm

Foley, J. A., DeFries, R., Asner, G. P., Barford, C., Bonan, G., Carpenter, S. R., et al. (2005). Global Consequences of Land Use. *Science, 309*(5734), 570-574.

Geist, H., & Lambin, E. (2002). Proximate causes and underlying driving forces of tropical deforestation. *Bioscience 52*(2), 143-150.

Gibbs, H., Ruesch, A., Achard, F., Clayton, M., Holmgrene, P., Ramankuttyf, N., et al. (2010). Tropical forests were the primary sources of new agricultural land in the 1980s and 1990s. *PNAS, 107*(38).

Guiang, E. (2001). Impacts and effectiveness of logging bans in natural forests: Philippines in Forests out of bounds. In P. B. Durst, T. R. Waggener, T. Enters & T. L. Cheng (Eds.) (Vol. Impacts and effectiveness of logging bans in natural forests in Asia-Pacific, Available from http://www.fao.org/docrep/003/x6967e/x6967e07.htm on November 30, 2010.

Izquierdo, A. E., & Grau, H. R. (2009). Agriculture adjustment, land-use transition and protected areas in Northwestern Argentina. *Journal of Environmental Management, 90*(2), 858-865.
Kamusoko, C., & Aniya, M. (2006). Land use/land cover change and landscape fragmentation analysis in the Bindura District, Zimbabwe. *Land Degradation & Development 18*(2), 221-233.
Kerr, J., & Cihlar, J. (2005). Land Use Mapping. *Encyclopedia of Social Measurement, 2*.
Koomen, E., & Stillwell, J. (2007). Modelling Land-Use Change. In E. Koomen, J. Stillwell, A. Bakema & H. J. Scholten (Eds.), *Modelling Land-Use Change* (Vol. 90, pp. 1-22): Springer Netherlands.
Kowal, N. E. (1966). Shifting cultivation, fire, and pine forest in the Cordillera Central, Luzon, Philippines. *Ecological Monographs, 36*(4), 389-419.
Lakshmanan, T., & Chatterjee, L. (2005). Economic consequences of transport improvements. *Access 26*.
Lakshmanan, T. R. (1989). Infrastructure and Economic Transformation In A. Andersson & e. al. (Eds.), Advances in Spatial Theory and Dynamics
Lambin, E., Geist, H., & Lepers, E. (2003). Dynamics of land-use and land-cover change in tropical regions. *Annual Review of Environment and Resources, 28*, 205-241.
Lambin, E., Turner, B. L., Geist, H. J., Agbola, S. B., Angelsen, A., Bruce, J. W., et al. (2001). The causes of land-use and land-cover change: moving beyond the myths. *Global Environmental Change, 11*(4), 261-269.
Malanes, M. (2002). *Power from the Mountains Indigenous Knowledge Systems and Practices in Ancestral Domain Management: The Experience of the Kankanaey-Bago People in Bakun, Benguet Province, Philippines*: International Labour Organization.
Mertens, B., & Lambin, E. F. (1997). Spatial modelling of deforestation in southern Cameroon : Spatial disaggregation of diverse deforestation processes. *Applied Geography, 17*(2), 143-162.
Meyer, W. B., & Turner, B. L. (1992). Human population growth and global land-use/cover change. *Annual Review of Ecology and Systematics, 23*, 39-61.
Millennium Ecosystem Assessment Report, Ecosystems and Human Well-Being: Synthesis. (2005). Washington.
Nagendra, H., Munroe, D. K., & Southworth, J. (2004). From pattern to process: landscape fragmentation and the analysis of land use/land cover change. *Agriculture, Ecosystems & Environment, 101*(2-3), 111-115.
Nepstad, D., Carvalho, G., Cristina Barros, A., Alencar, A., Paulo Capobianco, J., Bishop, J., et al. (2001). Road paving, fire regime feedbacks, and the future of Amazon forests. *Forest Ecology and Management, 154*(3), 395-407.
Olsson, J. (2009). Improved road accessibility and indirect development effects: evidence from rural Philippines. *Journal of Transport Geography, 17*(6), 476-483.
Overmars, K. P., & Verburg, P. H. (2005). Analysis of land use drivers at the watershed and household level: Linking two paradigms at the Philippine forest fringe. *International Journal of Geographical Information Science, 19*(2), 125 - 152.
Participatory Baseline Survey Report of the Bakun Indigenous Tribes Organization (1998).
Pattanayak, S. K., Wunder, S., & Ferraro, P. J. (2010). Show Me the Money: Do Payments Supply Environmental Services in Developing Countries? *Review of Environmental Economics and Policy, 4*(2), 254-274.
Pulhin, J. A. i. (1996). *Community forestry: paradoxes and perspectives in development practice.* Australian National University, Canberra.
Reyes-Boquiren, R. (1989). *The History and Political Economy of the Benguet Vegetable Industry*. Baguio City: Cordillera Studies Center, University of the Philippines Baguio.
Rist, S., Chidambaranathan, M., Escobar, C., Wiesmann, U., & Zimmermann, A. (2007). Moving from sustainable management to sustainable governance of natural resources: The role of social learning processes in rural India, Bolivia and Mali. *Journal of Rural Studies, 23*(1), 23-37.
Shively, G., & Martinez, E. (2001). *Deforestation, irrigation, employment and cautious optimism in Southern Palawan, the Philippines*. Cambridge: Cabi Publishing.
Singh, A. (1989). Digital change detection techniques using remotely-sensed data. *International Journal of Remote Sensing, 10*(6), 989-1003.
Tauli, A. (2009). A historical background to the land problem in the Cordillera. In J. Cariño, L. Gimenez, M. Loste & P. Verzola (Eds.), *Ti Daga Ket Biag (Land is Life), Selected Papers from Three Cordillera Multi-Sectoral Land Congresses (1983, 1994, 2001)*. Baguio City: Cordillera Peoples Alliance.
Turner, B. L., Matson, P. A., McCarthy, J. J., Corell, R. W., Christensen, L., Eckley, N., et al. (2003). Illustrating the coupled human-environment system for vulnerability analysis: Three case studies. *Proceedings of the National Academy of Sciences of the United States of America, 100*(14), 8080-8085.

Veldkamp, A., & Fresco, L. O. (1996). CLUE: a conceptual model to study the Conversion of Land Use and its Effects. *Ecological Modelling, 85*(2-3), 253-270.
Veldkamp, A., & Lambin, E. F. (2001). Predicting land-use change. *Agriculture, Ecosystems & Environment, 85*(1-3), 1-6.
Verburg, P. H., Overmars, K. P., Huigen, M. G. A., de Groot, W. T., & Veldkamp, A. (2006). Analysis of the effects of land use change on protected areas in the Philippines. *Applied Geography, 26*(2), 153-173.
Verburg, P. H., & Veldkamp, A. (2004). Projecting land use transitions at forest fringes in the Philippines at two spatial scales. *Landscape Ecology 19*, 77-98.
Vitousek, P. (1994). Beyond Global Warming: Ecology and Global Change. *Ecology and Society, 75*(7), 1861-1876.
Vitousek, P. M., Mooney, H. A., Lubchenco, J., & Melillo, J. M. (1997). Human domination of Earth's ecosystems. *SCIENCE, 277*(25), 494-499. .
Vitug, M. (2000). Forest policy and national politics. In P. Utting (Ed.), *Forest Policy and Politics in the Philippines: The Dynamics of Participatory Conservation*. Quezon City: Ateneo de Manila University Press.
Wiggins, S., Marfo, K., & Anchirinah, V. (2004). Protecting the Forest or the People? Environmental Policies and Livelihoods in the Forest Margins of Southern Ghana. *World Development, 32*(11), 1939-1955.
Willemen, L., Hein, L., & Verburg, P. H. (2010). Evaluating the impact of regional development policies on future landscape services. *Ecological Economics, 69*(11), 2244-2254.
World Development Report (Infrastructure Development). (1994). Oxford University Press.
Yin, R., Xiang, Q., Xu, J., & Deng, X. (2010). Modeling the Driving Forces of the Land Use and Land Cover Changes Along the Upper Yangtze River of China. *Environmental Management, 45*(3), 454-465.
Yu, W., Zang, S., Wu, C., & Na, W. L. X. (2010). Analyzing and modeling land use land cover change (LUCC) in the Daqing City, Chin. *Applied Geography, 31*, 600-608.
Zhang, S. Q., Na, X. D., Kong, B., Wang, Z. M., Jiang, H. X., Yu, H., et al. (2009). Identifying wetland change in China's Sanjiang plain using remote sensing. *Wetlands, 29*(1), 302-313.

ANNEXES

Annex 1. List of secondary sources

Date	Title	Source
1. Reports		
1998	Participatory Baseline Survey Report, Bakun, Benguet	Bakun Indigenous Tribal Organization
2007	Report on the Participatory Poverty and Livelihood Assessment (PALA) in Bakun, Benguet, Philippines	CHARM-RUPES
2007	Bakun Integrated Watershed Development and Management Plan (2007-2017)	Local Government of Bakun
2009	Annual Report, Municipality of Bakun	Local Government of Bakun
December 20, 1993	Memorandum of Agreement between the Municipality of Bakun and the Northern Mini-Hydro Corporation	Office of the Secretary of the Bakun Municipal Council
December 28, 1994	Memorandum of Agreement between the Municipality of Bakun and the Northern Mini-Hydro Corporation	Office of the Secretary of the Bakun Municipal Council
1997	Memorandum of Agreement among the Province of Benguet, Municipality of Bakun, Luzon Hydro Corporation and national Power Corporation	Office of the Secretary of the Bakun Municipal Council
2002	Ancestral Domain Sustainable Development and ProtectionPlan	Municipal Planning and Development Office (MPDO)
2. Maps		
2003	1:50,000 Topographic Map	MPDO
2010	Land Use Map	MPDO
2010	Watershed Map	MPDO
2010	River Network	MPDO
2010	Road Network	MPDO

Annex 2: Classification Accuracy Assessment Report

1. 1990

Error Matrix

Classified Data		Open for	Open area	Reference Data
Open forest	0	25	0	0
Open area/cultivated land	0	1	23	0
Grassland	0	2	0	0
Dense forest	0	2	0	0
Rice/cultivated land	0	0	2	0
Built up area	0	0	3	0
Water	0	0	1	0
Column Total	0	30	29	0
Classified Data	Grassland		Dense for	
Open forest	2	0	3	0
Open area/cultivated land	1	0	0	0
Grassland	24	0	0	0
Dense forest	0	0	27	0
Rice cultivated	0	0	0	0
Built up area	0	0	0	0
Water	0	0	2	0
Column Total	27	0	32	0
Classified Data	Rice culti		Built up a	
Open forest	0	0	0	0
Open area/cultivated land	3	0	0	0
Grassland	4	0	0	0
Dense forest	0	0	0	0
Rice cultivated	25	0	2	0
Built up area	2	0	23	0
Water	1	0	1	0
Column Total	35	0	26	0
Classified Data			Water	Row Total
Open forest	0	0	0	30
Open area/cultivated land	0	0	2	30
Grassland	0	0	0	30
Dense forest	0	0	1	30
Rice cultivated	0	0	1	30
Built up area	0	0	2	30
Water	0	0	25	30
Column Total	0	0	31	210
				----- End of Error Matrix -----

Accuracy Totals (1990)

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
Open forest	30	30	25	83.33%	83.33%
Open area/cultivated land	29	30	23	79.31%	76.67%
Grassland	27	30	24	88.89%	80.00%
Dense Forest	32	30	27	84.38%	90.00%
Rice cultivated	35	30	25	71.43%	83.33%
Built up area	26	30	23	88.46%	76.67%
Water	31	30	25	80.65%	83.33%
Totals	210	210	172		
Overall Classification Accuracy					81.90%
					----- End of Accuracy Totals -----

Kappa (K^) Statistics

Overall Kappa Statistics = 0.7889

Conditional Kappa for each Category.

Class Name	Kappa
Open forest	0.8056
Open area/cultivated land	0.7293
Grassland	0.7705
Dense forest	0.882
Rice cultivated	0.8
Built up area	0.7337
Water	0.8045

----- End of Kappa Statistics -----

2. 2002

Error Matrix

Classified Data		Open for	Open area	Reference Data
Open forest	0	22	0	0
Open area/cultivated land	0	0	22	0
Grassland	0	4	0	0
Dense forest	0	5	0	0
Rice cultivated	0	0	2	0
Built up area	0	0	3	0
Water	0	0	2	0
Column Total	0	31	29	0
Classified Data	Grassland		Dense forest	
Open forest	2	0	4	0
Open area/cultivated land	0	0	0	0
Grassland	21	0	0	0
Dense forest	3	0	21	0
Rice cultivated	3	0	0	0
Built up area	0	0	0	0
Water	0	0	1	0
Column Total	29	0	26	0
Classified Data	Rice culti		Built up a	
Open forest	1	0	1	0
Open area/cultivated land	3	0	4	0
Grassland	2	0	3	0
Dense forest	0	0	0	0
Rice cultivated	23	0	2	0
Built up area	2	0	25	0
Water	3	0	0	0
Column Total	34	0	35	0
Classified Data			Water	Row Total
Open forest	0	0	0	30
Open area/cultivated land	0	0	1	30
Grassland	0	0	0	30
Dense forest	0	0	1	30
Rice cultivated	0	0	0	30
Built up area	0	0	0	30
Water	0	0	24	30
Column Total	0	0	26	210
---- End of Error Matrix -----				

Accuracy Totals (2002)

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
Open forest	31	30	22	70.97%	73.33%
Open area/cultivated land	29	30	22	75.86%	73.33%
Grassland	29	30	21	72.41%	70.00%
Dense forest	26	30	21	80.77%	70.00%
Rice cultivated	34	30	23	67.65%	76.67%
Built up area	35	30	25	71.43%	83.33%
Water	26	30	24	92.31%	80.00%
Totals	210	210	158		
Overall Classification Accuracy					75.24%
----- End of Accuracy Totals -----					

KAPPA (K^) STATISTICS

Overall Kappa Statistics = 0.7111

Conditional Kappa for each Category.

Class Name	Kappa
Open forest	0.6872
Open area/cultivated land	0.6906
Grassland	0.6519
Dense forest	0.6576
Rice cultivated	0.7216
Built up area	0.8000
Water	0.7717

----- End of Kappa Statistics -----

3. 2007

Error Matrix

Classified Data		Open for	Open area	Reference Data
Open forest	0	27	0	0
Open area/cultivated land	0	1	23	0
Grassland	0	4	0	0
Dense forest	0	1	0	0
Rice cultivated	0	0	2	0
Built up area	0	0	4	0
Water	0	0	2	0
Column Total	0	33	31	0
Classified Data	Grassland		Dense for	
Open forest	2	0	0	0
Open area/cultivated land	2	0	0	0
Grassland	22	0	1	0
Dense forest	0	0	23	0
Rice cultivated	0	0	0	0
Built up area	0	0	0	0
Water	0	0	0	0
Column Total	26	0	24	0
Classified Data	Rice culti		Built up a	
Open forest	0	0	0	0
Open area/cultivated land	0	0	2	0
Grassland	3	0	0	0
Dense Forest	1	0	0	0
Open area/cultivated land	23	0	3	0
Built up area	0	0	23	0
Water	3	0	0	0
Column Total	30	0	28	0
Classified Data			Water	Row Total
Open forest	0	0	1	30
Open area/cultivated land	0	0	2	30
Grassland	0	0	0	30
Dense Forest	0	0	5	30
Rice cultivated	0	0	2	30
Built up area	0	0	3	30
Water	0	0	25	30
Column Total	0	0	38	210
				---- End of Error Matrix -----

Accuracy Totals (2007)

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
Open forest	33	30	27	81.82%	90.00%
Open area/culti	31	30	23	74.19%	76.67%
Grassland	26	30	22	84.62%	73.33%
Dense Forest	24	30	23	95.83%	76.67%
Rice cultivated	30	30	23	76.67%	76.67%
Built up area	28	30	23	82.14%	76.67%
Water	38	30	25	65.79%	83.33%
Totals	210	210	166		
Overall Classification Accuracy					79.05%
----- End of Accuracy Totals -----					

Kappa (K^) Statistics

Overall Kappa Statistics = 0.7556

Conditional Kappa for each Category.

Class Name	Kappa
Open forest	0.8814
Open area/cultivated land	0.7263
Grassland	0.6957
Dense Forest	0.7366
Rice cultivated	0.7278
Built up area	0.7308
Water	0.7965

----- End of Kappa Statistics -----

Annex 3. Summary of changes from one class to another class

1990 land use/land cover to 2007 land use/land cover	Ha	1990 land use/land cover to 2007 land use/land cover	Ha
Dense forest to open forest	1,523	Open/cultivated land to dense forest	249
Dense forest to grassland	798	Rice/cultivated land to built-up area	235
Dense forest to rice/cultivated area	778	Built-up area to grassland	232
Dense forest to built-up area	723	Grassland to built-up area	226
Dense area to cultivated land	624	Grassland to rice/cultivated land	211
Open forest to grassland	610	Open/cultivated land to built-up area	197
Grassland to open/cultivated land	604	Open/cultivated land to grassland	192
Open forest to open/cultivated land	584	Water to dense forest	188
Built-up area to open/cultivated land	584	Built-up area to open forest	187
Open forest to dense forest	570	Rice/cultivated land to grassland	179
Grassland to open forest	555	Built-up area to water	174
Grassland to dense forest	509	Water to open forest	151
Rice/cultivated land to open/cultivated land	480	Open forest to water	138
Water to open/cultivated land	450	Water to rice/cultivated land	127
Built-up area to dense forest	399	Open forest to built-up area	112
Rice/cultivated land to dense forest	375	Water to built-up area	107
Open/cultivated land to water	335	Rice/cultivated land to open forest	105
Open/cultivated land to rice/cultivated land	300	Grassland to water	75
Open/cultivated land to open forest	297	Water to grassland	60
Built-up area to rice/cultivated land	280	Open forest to rice/cultivated land	32
Dense forest to water	278	**Rice to water**	**1334**