1 Economic Development and Watershed Degradation

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Agricultural Development and Environmental Change

In recent decades the protection and management of watersheds has emerged as both a local and national policy imperative throughout the developing world, especially in densely populated regions of South and South-east Asia (Asian Productivity Organization, 1995; Heathcote, 1998; World Bank, 1992).[1] Throughout Asia, growing populations and mismanagement of complex, fragile and poorly understood ecosystems continue to jeopardize the livelihoods of local populations as well as the prospects for environmental protection and rehabilitation. Moreover, across many tropical landscapes, areas of environmental concern closely coincide with pockets of poverty. The biophysical links between upland farms and downstream water users have been well documented for some time. However, policies to promote sustainable use of watersheds populated mainly by the very poor remain elusive.

In this book we ask how economic development, and in particular agricultural development, influences watershed health. We define economic development to mean both economic growth and institutional evolution. Our empirical focus is on a single agricultural landscape, the Manupali River watershed in southern Philippines; however, lessons from this location apply well beyond the borders of the watershed, or indeed the Philippines or South-east Asia. The contributions to this book aim to improve understanding of the general forces influencing patterns of land use in tropical agricultural landscapes. The interface between human activity and the local environment is of central concern, but we also attempt to answer questions of how best to manage natural resources so as to sustain agricultural livelihoods, and how best to minimize environmental damages arising from agricultural activities.

For more than a decade, the standard references on watershed-related themes in Asia have been included in books edited by Easter *et al*. (1986) and Doolette and Magrath (1990). These books remain important, not least for having drawn attention to watersheds as 'units of analysis' in their own right. Doolette and Magrath (1990: 2) pointed out that

> watershed problems are . . . connected by the fact that they can best be understood and dealt with in the context of physical planning units defined by the flow of water.

Similarly, Dixon and Easter (1986: 9), in their introductory chapter to the book edited by Easter *et al.* argued that

> watersheds, analyzed and managed in an integrated manner, are a useful tool for planning and implementing rural development efforts . . . [t]he question . . . is how the resources within a watershed should be used to obtain a socially optimal level of production over time.

This focus on the watershed as a proper unit of analysis for questions relating to agricultural development has served as an organizing principle for much of [a1] the research undertaken since (e.g. Munasinghe, 1992; Naiman, 1995). The landscape orientation was, in fact, a cornerstone for the larger project of which the research reported in this book is a part.

Despite widespread acceptance of the watershed as a unit of analysis, over the past decade several additional themes have emerged that demand a re-examination of the forces shaping land use in tropical watersheds and suggest the need to update the development dialogue of the early 1990s. First among these is the often rapid economic integration of watershed economies with the national economies in which they exist, especially as this integration arises through the maturation of transport and telecommunications infrastructure and the growth of input, product, and domestic labour markets. Second, globalization has meant that international trade patterns now often strongly influence patterns of agricultural production in tropical watersheds. Third, the process of decentralization has expanded the scope for local political jurisdictions to shape patterns of economic development – for better or for worse. And fourth, civil society (often through non-governmental organizations) can increasingly be found participating in the decision making process.

A second force shaping our work is the rapid advance in both the number and the sophistication of available modelling tools. While technological constraints meant that earlier studies could only point to the need for GIS-based tools and integrated economy – environment models, we can now report results obtained using these. Moreover, because the contributors to this book have been engaged in data collection in one site for more than a decade, we have an unprecedented amount of high-quality data (especially biophysical and panel survey data) available to study watershed-scale phenomena. These data lead us to conclude that many of the problems and issues relevant to watersheds transcend their physical boundaries. In other words, understanding the flow of water is rarely sufficient for understanding watershed health. People, goods and ideas all flow into and out of watersheds, and this necessitates a view of the watershed both as an integrated biophysical system and as part of a much larger economic system.

It is exactly such a view that we hope to promote in this book, which as a whole seeks to illuminate connections between human and natural systems as they exist in both space and time. At a conceptual level, these connections include an interlinked set of biophysical, economic and social features that evolve in response to human desires and needs on the one hand, and to environmental health and resilience on the other. At a more practical level, one recurrent theme in the book is that both the magnitude and the strength of human–environment connections are influenced by a broad range of factors (e.g. market signals and institutional performance) that are shaped by local, regional and national policies. Although it is clear that physical and economic outcomes observed on small farms result from household decisions and the physical features of the landscape, it is the primary thesis of this book that a broader perspective is required. Local and immediate outcomes reflect prevailing conditions in markets in which households participate. Crops and cropping systems are chosen by households from a set constrained, in part, by the choices and trade-offs made by national governments and international markets and organizations. And patterns of innovation, adoption and adaptation reflect the social fabric of which rural households are a part. Decisions made by smallholders can be traced to local economic conditions, and these local conditions, in turn, can be seen to be filtered through local institutions, local rules and social norms. But local economic conditions are also products of national and international economic signals, and are shaped by the performance of regional markets.

The enabling and conditioning factors influencing watershed outcomes include global economic conditions, national government policies, and regional market performance. When combined with a standard list of local factors, such as local economic conditions, biophysical features of the landscape, and farm-level constraints on activity, this list suggests not only multiple points of entry for researchers and policymakers concerned with patterns of agricultural land use, but also the need for a multi-disciplinary perspective to understand how decisions and outcomes are influenced by economic, social and biophysical features of a landscape. The relationships and linkages of interest in this book are those spatial and temporal connections among economic incentives, social and biophysical conditions and environmental outcomes.

Most of the chapters that follow examine land use changes retrospectively, asking how features of the landscape have evolved in response to key variables of interest. But we also undertake the more difficult task of looking ahead, asking how the agricultural landscape might change in response to changes in policies, institutions or economic signals. Throughout, we maintain our focus on the watershed as a unit of analysis, utilizing a number of techniques to explain and predict land use changes and outcomes at this scale. These approaches include systems-based models, process-oriented simulation models, statistical analysis and GIS-based methods, and participatory techniques that have involved local communities in the measurement and understanding of land use changes in their communities.

Geographical and Historical Context for the Book[2]

The setting for this book is a watershed in the uplands of South-east Asia. These present a rich and diverse natural environment. Over the past 50 years, however, they have been subject to timber extraction, intensified subsistence farming, plantation establishment and other commercial activities that increasingly include highly capital-intensive horticulture and livestock rearing operations. The expansion and commercialization of agriculture and rural industries has been driven by a combination of demand factors (especially the search for land and forest as complements to labour), supply factors including unregulated access to many resources, and reduced transactions costs due to the expansion of roads and other infrastructure. Without the necessary policy and institutional support for environmental management, these activities have denuded forest cover, polluted rivers, eroded soils and diminished biodiversity. In many areas, deterioration of the natural environment has reached the point at which the viability of future production activities on the same resource base is in question.

Case studies of resource depletion associated either with rapid economic growth or with poverty-driven environmental degradation (e.g. Perrings, 1989) abound in the literature. Many of these identify ‘institutional failures’ that have created open access to natural resources as an enabling condition. A longer time perspective, however, reveals that open access was not always the norm in uplands; nor, if the experience of comparable areas in wealthy countries is a guide, does this institutional failure persist as economies develop. Clearly, the ways in which economic growth interacts with institutions and influences their evolution are potentially very important determinants of the uses of natural resources and thus (through feedback mechanisms) of the health of upland economies themselves.

Historically, patterns of economic and agricultural development in upland areas have been accompanied by distinct phases of institutional development. We illustrate these phases of agricultural and institutional co-evolution in Fig. 1.1, and provide additional details regarding their characteristics in Table 1.1. In the first phase, prior to colonization or massive internal migration, upland populations are sparse and production is primarily for subsistence, and natural resource use is governed by local customary laws. Tribes and communities manage the resources over which they have control. These institutions are effective as means to govern the commons, not least because demand for the resources is low, technologies for their exploitation are limited, and transport infrastructure is poor. Long-rotation bush farming fallow systems, typical of this era of development, are widely regarded as ‘sustainable’.

Economic development and population growth in coastal cities and lowland rural areas quickly change the upland economy. Commercialization (driven by the expansion of domestic and global markets), migration and natural population increase, and the introduction of new technologies all create new pressures on the resource base. Customary law cannot easily accommodate such changes.[3] In this second phase of institutional development, traditional resource use institutions are swept aside (or merely recede); the state

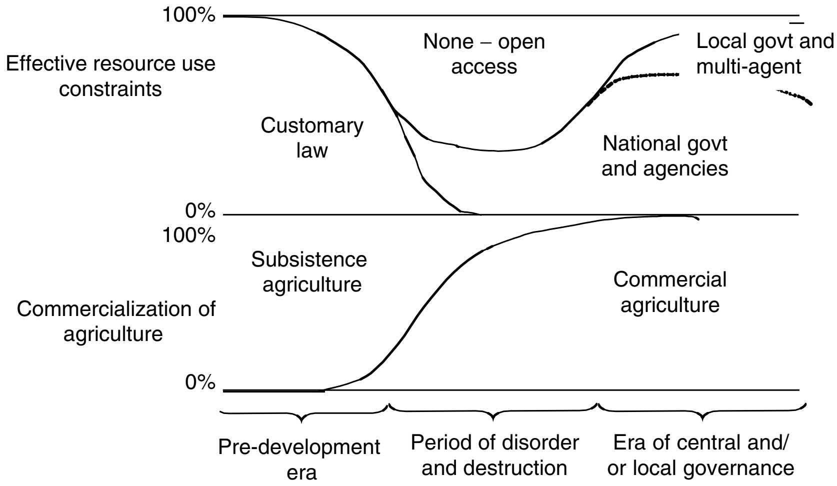

Fig. 1.1. Co-evolution of markets and institutions at the agricultural frontier.

assumes the lead role in controlling resource use and access, and new resource management institutions are imposed from the outside. But even though local governments and local offices of national resource management agencies may be established, these have no autonomy and little effective authority or capacity for enforcement. State power is thus low at the frontier; the resource base becomes, in effect, open access. Moreover, not only is there no political will for environmental or resource use measures that might reduce current income generation opportunities of people living in severe poverty amidst a perceived

Table 1.1. Economic development and institutional evolution for environmental management.

	Subsistence economy	Early development	Late development
Economy and resource use	• Low population growth • Little or no migration • Resource abundance • Subsistence agriculture • Slash-and-burn • Long fallow periods	• High population growth • In-migration • Resource competition • Intensive agriculture • Commercial activity • Fallows shorten	• Population density falls • Out-migration • Resource use intensity falls • Mature agriculture • Commercial economy • Reforestation/protection
Institutional evolution	• Customary Law • Community resource management	• State institutions with Ideally: no practical checks • Property rights not well defined • 'Land grabs'	• Central and local institutional change • Community stewardship • Property rights well defined Alternately: • Local elites gain power • Incentives incompatible with benefits

abundance of natural resources, but also the state typically *promotes* resource depletion as a means to generate household income and fiscal revenues. What follows is rapid deforestation, shortening of fallow periods and general degradation of soil, water and other environmental resources.

This 'period of disorder and destruction', as Burch (1990) describes it, was characteristic of many upland regions from the 1960s to 1990s, during which time South-east Asia established itself as the world region with the highest annual deforestation rate (FAO, 2001), even as its largest resource-abundant economies (Indonesia, Malaysia and Thailand) expanded at historically unprecedented rates. Elsewhere, in highly repressed economies such as Myanmar, Laos and Vietnam, the state itself became the primary agent and entrepreneur of resource depletion, having closed off most other means to generate jobs, government revenue and foreign exchange.

In South-east Asia's more open economies, economic maturation and the end of the demographic transition has ushered in a third development phase, one in which lower labour force growth and rapid job creation outside of agriculture greatly reduce population-driven demand for upland resources, especially land. This has potentially large implications for the governance of such resources. In our view, this phase may result either in continued rapid resource depletion or in a shift to more conservative strategies. Which of these is more likely to occur? This will depend largely on the speed with which institutions catch up with the pace of economic growth. The countries of the region currently present a fascinating array of trends, with no clear, single pattern having emerged.

In this third phase, there is growing community demand for environmental quality and resource conservation. This trend is complemented by a more general decentralization of power and authority, as currently is taking place through formal means in all the large economies of the region. In some places, as local governments and communities assume control over some aspects of resource management, there may be a reassertion of customary laws, although in modified form. In the best situations, a combination of decentralization plus local demands for more ecologically-friendly development is complemented by national laws and policies; in the best outcomes, national agencies, local governments and community groups collaborate to design (and more importantly, to implement) resource management and policies. In the worst cases, however, with continued growth of market demand for resources, reduced power at the national government level, and a 'business as usual' attitude on the part of local elites, 'disorder and destruction' continues, or even worsens.

A Review of Economy–Environment Linkages

Virtually all production generates some environmental damage in the form of pollution and/or natural resource depletion, and it follows that, other things being equal, such damage or depletion increases as an economy expands. It is well known, however, that the economy–environment relationship can be nonlinear – and indeed, non-monotonic, a concept widely referred to as the

Environmental Kuznets Curve. Changes in economic structure occurring in the course of economic growth alter both the valuation and demand for environmental assets, and if sectors differ in their propensity to pollute or to use depletable resources, it follows that emissions and/or depletion rates will also change, a phenomenon that has been termed the *composition effect*.[4] The net environmental impacts of structural change can either be harmful or benign; more importantly, perhaps, the aggregate composition effect in fact has many elements, each with its own specific set of underlying economic and institutional determinants. For land and forest issues, this analytical approach enables research to move beyond trivially true assertions that deforestation and upland land degradation are the consequences of population pressure and 'market forces'. One thing that quickly becomes clear is that while *total* population growth in a country may justifiably be regarded as beyond the reach of policy except in the very long run, its spatial distribution, and the incentives that upland populations face when making resource use decisions, are very heavily conditioned by government policies, both those directly targeting such populations and activities, and also those operating at the broadest level of the economy.[5]

Upland agricultural development

The economies of Asia's uplands – usually defined officially by slope and/or altitude, but in practice referring also to relatively remote agricultural areas – differ both in structure and level of development by comparison with lowland zones. They are less densely populated and more dependent on agriculture and other resource-based industries; their populations are poorer, less healthy and less well educated. Market access is constrained by higher transport and transactions costs. Though accurate counts are impossible, the population living on 'fragile' lands in Asia and the Pacific is currently estimated at 469 million, or 25% of total population (World Bank, 2003).[6]

As recently as a generation ago, many upland populations were effectively isolated from lowland and non-farm economies by infrastructural constraints, travel costs and even ethnic and political divisions. In spite of continued remoteness and relatively poor infrastructure, however, upland population trends, markets, policies and institutions are now very strongly influenced by the development of the overall economy. Roads and telecommunications networks integrate upland producers with the national economy. As markets expand, they create new economic opportunities, which upland and migrant populations are generally quick to seize. In so doing, they also alter the value of immovable resources such as forests and land. In a subsistence economy, such resources (and even labour) have values derived only from the requirements of the local economy, but market integration requires that resource valuations reflect returns obtainable in new uses.

Development policies have direct effects in South-east Asian uplands largely through infrastructure provision. The impact of road construction is huge, since it fractures natural landscapes, altering forest edges and interiors at the same time it reduces transport costs and accelerates flows of migrants and information. As elsewhere in the developing world, road construction has a strong association with deforestation and the spread and intensification of agriculture (Cropper *et al*., 1997; Andersen *et al*., 2002).

The expansion of roads and markets, however, also conveys the *indirect* effects of policy distortions to upland resource use decisions, so economic and policy trends in industry and lowland agriculture become central to upland development (Coxhead and Jayasuriya, 2003), and national trends in food demand, agricultural technology, and food policy can all have significant environmental consequences. Most obviously, agricultural support policies may stimulate the expansion of cultivated area at the expense of forest. The mechanisms for this change vary from country to country and over time, with contributions from state-sponsored land clearing for settlement programmes, commercial forestry and subsequent land conversion by corporate agribusiness enterprises, and deforestation and land clearing (as well as the intensification of bush fallow rotation systems) by 'subsistence' farmers (Angelsen, 1995). All land colonization, however, is driven by a combination of opportunity and necessity, and encouraged by the absence of well-defined and effectively enforced property rights over forest-covered land. As we have argued, the property rights problem itself is partly an artifact of government policies that identify forest-covered land (or land so designated, including cleared land above a certain slope or altitude) as a public resource, neither alienable nor disposable, without providing adequately for its protection from encroachment.

Lowland agricultural development

Whereas much of Asia was historically a region of food surplus and labour scarcity, 20th century population growth soon began to apply pressure on the agricultural land base. In the three decades after the Second World War, a period during which the region's population grew very rapidly, pressures on the land resource base began to climb, domestic food production per capita began to decline and the share of food in the value of imports began to rise. Investments in irrigation, and the introduction of yield-improving technology packages in the 1960s and 1970s, which centred on modern cereal varieties (the 'green revolution'), partially alleviated land scarcity by enabling production increases on existing land. In addition, states sponsored the colonization of new lands for food production through internal migration, supported by subsidized or publicly provided services such as land clearing and market and physical infrastructure.

Within agriculture as a whole, and in lowlands in particular, cereal production dominates land use and sectoral employment. It follows that technical progress in cereals – the green revolution – and food policies have significant effects on agricultural development. Governments of the net food-importing Asian economies have enshrined food security – or more strongly, self-sufficiency in cereals at the national or even subnational scale – as a basic plank of development policy (Barker and Herdt, 1985; David and Huang, 1996). The key instruments of self-sufficiency strategies have been quantitative restrictions on food trade, usually with monopoly control over imports assigned to a state agency. Historically, these policies, along with the industrialization policies discussed above, did much to determine resource allocation and investment flows both to agriculture as a whole, and to industries within that sector.[7] In the 1990s many such policies were converted to tariffs to comply with WTO rules. However, WTO rules on agricultural import policies by LDCs permit ample margins for maintenance of previous trade regimes, albeit with new instruments.

Outside of irrigated areas, the *direct* productivity impacts of infrastructural investments and new technologies in lowlands are generally small (David and Otsuka, 1994). When international trade is constrained, however, yield gains in lowland irrigated areas almost certainly diminish pressures for expansion of food production in uplands by driving down domestic grain prices. Rising labour productivity and labour demand in lowland agriculture also reduce incentives for labour migration to uplands (Coxhead and Jayasuriya, 1994; Hayami and Kikuchi, 2001; Shively, 2001). Historically, and even today, these indirect impacts of the green revolution confer environmental benefits in uplands, raising the opportunity cost of deforestation and land conversion (Coxhead and Jayasuriya, 2004; Shively and Fisher, 2004; Shively and Pagiola, 2004).

Philippine Economic Development and the Uplands

Since the 1950s, in response to new commercial opportunities, land used for agricultural purposes has expanded considerably in the Philippines. At the end of the Second World War, most sloping and high-altitude land in the country was still forested. Agricultural activities in these areas consisted primarily of maize, cassava and coffee production. Various forms of long fallow were employed by farmers. In the province of Benguet in Northern Luzon, commercial vegetable production intensified, and in the 1950s, farmers migrating out of this highland area introduced commercial cultivation of potatoes, cabbages and other temperate-climate vegetables to similar areas elsewhere. Commercial success in these crops, the introduction of new maize varieties, and the substitution of coffee and shrub crops with annual crops resulted in a steady intensification in upland land use in many areas of Mindanao, the country's largest and least densely populated island. Since the late 1970s, improvements in infrastructure, integration of frontier economies into national agricultural markets, and growing domestic demand for maize and temperate-climate vegetables have ensured that commercial agriculture in upland areas continues to expand.

The Manupali River Watershed

Physical characteristics of the watershed

The research highlighted in this book was conducted in the Manupali River watershed, located in the Philippine province of Bukidnon, over more than 10 years, beginning in 1992 (for the location of the study site, see Plate 1).

This watershed shares many of the historical and institutional features highlighted in previous pages and consists of two political jurisdictions: the municipality of Valencia, which covers the southern side of the upper watershed, and the municipality of Lantapan, which covers the northern side of the watershed. Lantapan covers the largest part of the watershed – 31,652 ha out of a total watershed area of approximately 38,000 ha (see Plate 2).

The municipality of Lantapan is bounded in the south by the left bank of the Manupali River, and in the north by Mt Kitanglad Range Natural Park, a major national park. From east to west the landscape begins as river flats devoted to irrigated lowland rice fields at 300–600 m above sea level, and extends through rolling areas planted to sugarcane and maize into a band of maize and coffee at 600–1100 m. Agriculture terminates in a mid-to-high altitude area of maize and vegetable production that extends from about 800 m into the buffer zone of the national park at 1500 m. Steeply sloped mountainsides extend to 2900 m. The watershed has a mean elevation of 1561 m and a highest point of 2939 m. More than two-fifths of the area has a slope of 40% or more; of the remaining area 29% is rolling and 27% is considered flat. An aerial photograph of the watershed is provided as Plate 3. A map of the watershed, including major towns, roads and waterways appears as Plate 4. Below our study site the Manupali River runs into a diversion dam feeding a 4000 ha gravity-fed irrigation system constructed by the Philippines' National Irrigation Authority in 1987. The entire system ultimately drains into the Pulangi River, one of the major waterways of Mindanao Island, about 50 km upstream from the Pulangi IV hydroelectric power generation facility, the largest such facility in Mindanao and one of the largest hydroelectric power–generating plants in the country.

Mt Kitanglad Range Natural Park was established in 1996 and has a total area of 42,700 ha, with 31,236 ha designated as a protected area and 16,034 ha designated as a buffer zone. Approximately 45% of the total park area is covered with old-growth forest and much of the park remains forested, in spite of adjacent human activity. As Garrity and Amoroso (1998) point out, the area is a rich repository of biodiversity and a source of many environmental services and forest products. Although Mt Kitanglad Range Natural Park is a relatively small ecosystem, it has been judged to be of high conservation value due to high rates of endemism of the vascular flora (Amoroso *et al*., 1996; Pipoly and Maslulid, 1995). It has one of the greatest diversity of mammals and birds in the Philippines (Heaney, 1993) and an extremely high density of tree species. As an example, a 1-ha tree inventory conducted by Tabaranza (1995) and Pipoly and Madulid (1996) indicated the presence of 43 species, 47% of them endemic to the Philippines. This is one of the highest known tree species density figure for any published tropical tree inventory.

Forest cover, however, is shrinking, and the buffer zone area surrounding the park continues to degrade. GIS evidence from the watershed indicates substantial changes in land use and land cover over the past 20 years. A range of problems associated with this conversion of forest to agriculture in the watershed have been documented (Deutsch *et al*., 1998). Findings from water monitoring in subwatersheds of the Manupali River show persistently rising total suspended solids (TSS) loadings, along with other indicators of diminution in watershed function. In some instances, events have been dramatic: in one recorded event, TSS loadings increased by 1000-fold within a two hour period of heavy rain, to reach about 18 kg of soil in each cubic metre of water. The instability of some tributaries appears to be intensifying, as indicated by abrupt flooding and drought cycles resulting in washouts along main roads, property damage, and crop and soil losses. Such patterns of soil and water transport also pose health risks.

Water quality and human activity are closely linked in the Manupali River watershed. Abrupt increases in TSS have been observed after land conversion caused forest cover in a subwatershed to drop below 30% and the share of agricultural land to rise above 50%. Downstream, lowland farmers have become increasingly aware of the negative impacts of upland soil erosion due to heavy siltation of irrigation canals. In some cases, lowland water conveyance systems are only about 25% efficient. It also appears that the siltation problem in the downstream irrigation canal network has been intensifying. According to local observers, the amount of silt removed from downstream canals between 1993 and 1995 was more than twice the amount removed between 1990 and 1992. Last, but by no means the least, bacterial concentrations in tributaries of the Manupali River typically exceed WHO and US EPA safety standards for contact by a factor of 10–50.

The Manupali River is a source of water for drinking and irrigation, and – as mentioned above – is a tributary of the Pulangi River, which hosts several hydroelectric power plants, including the Pulangi IV facility. This power plant is a 255 MW run-of-the-river station that currently suffers from sedimentation so severe that its official expected life has been severely shortened.

Population and watershed economy

In many important respects – including a history of agricultural expansion, the persistence of poverty, and a worsening of on-site and downstream environmental quality – the Manupali River watershed shares features common to many tropical watersheds. The human population of the watershed is diverse. In the 1970s, Lantapan's population increased from 14,500 to 22,700 at an average annual rate of 4.6%; by 1994 the population exceeded 39,000 (Lantapan, 1994). Between 1980 and 1990 the population growth rate in this region averaged 4% per year, a rate that was much higher than the Philippine national average of 2.4%. In the most recent decade, however, population growth has fallen to roughly the same level as the national average.

The main indigenous population group is the *Talaandig*, who constituted 43% of the municipal population in 2001. Mt Kitanglad area is their ancestral home; they retain rights and have asserted claims over much of the land and resources in the watershed. Various migrant communities are also present, however, and immigration, mainly from the poorest provinces of the Central Philippines, has been a historically important determinant of activities.

The current population is a mix of indigenes with in-migrants of one, two or in a few cases three generations' duration.

Not surprisingly, agriculture is the primary sector of employment and the major determinant of land use in the area. In 1988, 71% of provincial employment was in agriculture, 5% in industry, and 23% in services; agriculture provides the primary income source for 68% of Bukidnon households. As is typical of a recently settled area, most Lantapan farms (about 70%, covering 80% of total farm area) were owned or in 'owner-like possession' in 1980, the last year for which agricultural census data are available. Farm sizes are small by upland standards: in Lantapan in 1980, the modal farm size class (1–2.99 ha) contained 46% of farms and 75% of all farms were smaller than 5 ha. Many households live close to the poverty line. In 1988, food accounted for 59% of household expenditures in Lantapan.

In 1973, approximately 28% of total land area in Lantapan was considered agricultural land and was used in the cultivation of temporary crops.[8] By 1994 this share had increased to nearly half of the watershed area. This expansion in land devoted to agriculture has largely involved the replacement of forest and permanent crops by annual crops. As is clearly seen in Table 1.2, over the 20-year period ending in 1994, the area of permanent forest shrank from approximately one-half to slightly more than one-quarter of the total land area. While a portion of this area was converted to shrubs or secondary forest, a much larger portion was changed to annual agricultural crops. Of special note is the expansion of land devoted to maize-vegetable systems; between 1973 and 1994, land allocated to these purposes increased from 17% to 33% of total land area. In early times, both logging and forest fires facilitated agricultural expansion. In recent decades, however, the profitability of commercial vegetable cultivation has been the primary impetus for forest encroachment, with decisive contributions from road development and the lack of well-defined and enforced property rights in land (Cairns, 1995). The expansion of vegetables and plantation crops in lieu of cereal crops in the area is also a result of favourable price and trade policies.

Table 1.2. Land use by slope (10% and greater), 1973 and 1994.

	Slope					
	10–20%	20–40%	40–90%			
Land use class	1973	1994	1973	1994	1973	1994
Dense forest	69.5	38.9	88.3	59.9	91.7	57.3
Shrub and tree (besides forest)	3.0	11.1	6.2	22.7	3.9	32.5
Shrub and tree (other distribution)	4.0	5.2	1.2	1.7	1.4	0.9
Agriculture	17.6	41.8	3.4	13.1	1.9	7.0
Grass	4.1	..	0.17	..	0.85	..
Bare soil	0.1	1.3	0.2	2.0	0.1	2.3
River and creek	1.7	1.7	0.5	0.5	0.1	0.1

Note: .. indicates data not available.
Source: Bin (1994), Tables 5.5 and 5.11. Data constructed from satellite imagery.

A number of economic phenomena have helped shape the observed pattern of land use, particularly the expansion of agriculture across the landscape and its intensification in certain locations. One of the most important economic drivers of these phenomena is movements in relative prices. On the commodity side, relative prices have changed in a discernible way over time, favouring annual crops such as maize and vegetables over perennial crops throughout most periods. Trends in input prices have also been influential in determining crop mixes, as the major crops differ considerably in their employment of factors. For these reasons, markets and national economic policies have played a key role in determining observed land use patterns in the watershed. For example, the profitability of maize and vegetable cultivation has been both directly and indirectly affected by Philippine government policies. Such policies consist mainly of market interventions intended to stabilize farm prices, trade interventions intended to defend the livelihoods of upland farmers and to reduce national dependence on imports, and technology interventions such as public support for research aimed at raising yields and reducing crop vulnerability to pests and diseases (Librero and Rola, 1994). The outcome of these interventions has been an increase in the area of maize planted in Bukidnon even as it has declined nationally in the Philippines (Coxhead, 1997, 2000).[9]

An important implication of expanded maize and vegetable production in the Manupali River watershed has been a steady decline in forest cover, an increase in erosion and sedimentation and an increase in the rate of pesticide use. Traditional crops, cropping systems and farming practices in the watershed remain problematic in this regard, although some technical solutions to the challenges of upland farming show promise. Furthermore, starting in 1998, at least ten commercial hog and poultry firms established a presence in the watershed; and in 1999 two banana companies were established in the middle and upper parts of the watershed. These activities place new strains on land and water resources and make it clear that steps to improve land use patterns in the watershed will require much more than just technical innovations. Given the rapid pace of decentralization that has taken place in the Philippines in the last decade, it may be possible for local institutions and local governments to play a facilitating role in altering patterns of agricultural and nonagricultural activity.

Overview of Chapters

The main goal of this book is to provide a focused analysis of the Manupali River watershed, including biophysical evidence on watershed degradation, economic and institutional causes and potential remedies. Findings are derived from research efforts based on data collected in the Manupali River watershed between 1992 and 2004. The chapters fall into three groups, defined roughly by their focus on: (i) the definition of challenges; (ii) the economic context of land use changes; and (iii) analyses conducted using the watershed as a unit of analysis.

Chapters 2 and 3 set the stage for subsequent chapters by examining patterns of agricultural development and environmental degradation in the watershed. In Chapter 2, Rola and Coxhead examine the history of agricultural development in the watershed and highlight institutional transitions that have taken place. The environmental implications of these economic and institutional changes are highlighted in Chapter 3, where Deutsch and Orprecio present 10 years of water quality data from the watershed. Chapter 3 establishes the link between changes in the physical characteristics of the landscape and changes in water quality, thereby providing the necessary broad perspective for the remainder of the book. Thematically, Chapters 4, 5 and 6 constitute a second section, and provide a set of closely related economic studies. In Chapter 4, Coxhead, Rola and Kim use time series data from local and regional agricultural markets to show how national markets have shaped incentives for agricultural expansion and resource allocation at the forest margin. In Chapter 5, Coxhead and Demeke then conduct an analysis at the farm level, using household panel data to examine the factors – including agricultural prices – associated with land use change. Having established the necessary evidence that land use in the watershed responds to changes in national prices, Chapter 6 presents analysis undertaken at a broader scale. We ask how the upland economy fits within the overall Philippine economy, using results from a computable general equilibrium model. Taken together, the results from this second group of chapters clearly establish the economic context in which land use change has occurred in the Manupali River watershed.

Chapters 7–11 constitute a third thematic section of the book and share two features: all take the watershed as their unit of analysis and all focus on possible remedies for landscape scale resource degradation. In Chapter 7, Ella reports results from simulations of soil erosion and sediment yields in subwatersheds of the Manupali River, asking how changes in land use might alter rates of erosion and downstream sediment yields. In Chapter 8, Paningbatan uses GIS methods to map a series of erosion 'hot spots' in the watershed. This approach shifts the focus towards predictive analysis, in the process highlighting the potential importance of targeting efforts to improve land use practices. Exactly what might constitute agronomically feasible alternatives to traditional annual crop agriculture is the subject of Chapter 9, in which Midmore and colleagues assess a range of alternative farming systems for the uplands and their likely consequences for the agricultural landscape.

Two subsequent chapters return the book to an economic focus. In Chapter 10, Shively and Zelek address the question of how changes in policies, especially economic policies, might influence land use decisions. Using a simulation model they investigate combinations of local and national economic policy changes designed to alter the incentives for various forms of crop agriculture in the watershed. In addition to examining the impact of a range of policies on household welfare and downstream environmental outcomes, they assess the distributional and budgetary impacts of various policies, asking what combinations of policies might achieve environmental goals in the most cost-effective manner. In Chapter 11, Pagiola, delos Angeles and Shively highlight the potential role that might be played by providing payments for environmental services

(PES) to achieve environmental improvements. The book concludes with Chapter 12, in which Coxhead, Rola and Shively explore the evolving interface between national development policies and local institutions as they shape the upland environment of the Manupali River watershed.

Notes

[1] Concerns that erosion from upland farming creates sediment in downstream irrigation systems, reducing both their productivity and expected life, are especially important in light of evidence that a lack of reliable water supply precludes expansion and intensification of agriculture in many low-income areas of Asia (Myers, 1988; Svendson and Rosegrant, 1994; Rosegrant *et al.*, 2001). As an example, estimates from the Philippines suggest 74–81 million tonnes of soil is lost annually, and 63–77% of the country's total land area is affected by erosion (Forest Management Bureau, 1998). Sedimentation has reduced storage capacity at all of the Philippines' major reservoirs, and has measurably affected domestic water consumption, power generation, and irrigation. Over the last 25 years dry season irrigated area has fallen by 20–30% in several of the country's key irrigation systems (Forest Management Bureau, 1998).
[2] Parts of this section draw on Rola and Coxhead (2005).
[3] For an example of how customary rules of resource access are sometimes unable to adapt to rapid changes in technology, see Shively (1997).
[4] The composition effect is one of three normally identified in analyses of growth-environment linkages. The other two are the *scale effect* (the additional demand on environment and natural resources due to economic expansion), and the *technique effect*, capturing secular changes in technology and non-homothetic preferences, due to changes in the capital stock and changes in incomes, respectively. Unlike the composition effect, the signs of with the scale and technique effects are hypothesized to be unambiguous: scale effects increase environmental damages, and technique effects lessen them. See Antweiler *et al.* (2001).
[5] See Binswanger (1991) for an early analysis of policy influences on deforestation in the Brazilian Amazon.
[6] 'Fragility' is defined by criteria relating to aridity, slope, forest cover and soil type.
[7] South-east Asia's two largest food importers, the Philippines and Indonesia, each achieved self-sufficiency in rice (in 1970 and 1985 respectively) as the result of huge investments of public funds in rice production, R&D, and related infrastructure, with substantial land and other resources diverted from production of other crops (Barker and Herdt, 1985).
[8] This area excludes areas devoted to production of coffee, rubber, abaca, and other tree and shrub crops.
[9] In Chapter 6 we use an economy-wide model of the Philippines to show that, at constant prices, even modest technical progress in maize production (which has the same effects on farm profitability as a price rise) increases the area planted to maize.

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