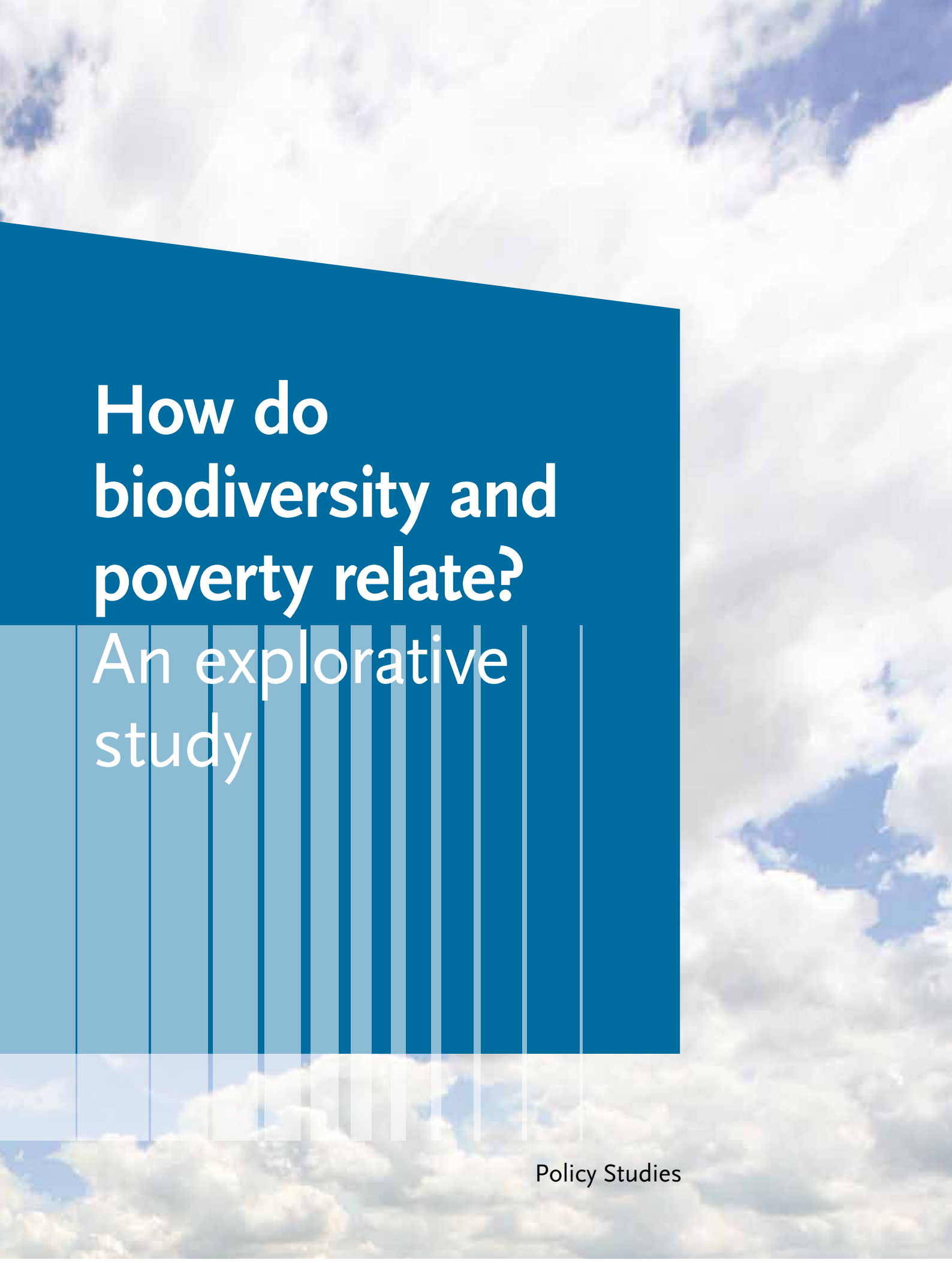

How do biodiversity and poverty relate?

An explorative study

Policy Studies

Netherlands Environmental Assessment Agency


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Netherlands Environmental Assessment Agency

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The Netherlands Environmental Assessment Agency (PBL) is the national institute for strategic policy analysis in the field of environment, nature and spatial planning. We contribute to improving the quality of political and administrative decision-making by conducting outlook studies, analyses and evaluations in which an integrated approach is considered paramount. Policy relevance is the prime concern in all our studies. We conduct solicited and unsolicited research that is both independent and always scientifically sound.

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Preface

The Netherlands Environmental Assessment Agency (PBL) has been assigned by the Dutch Government to contribute to several publications of international conventions and the UN, such as the Millennium Ecosystem Assessment (2005); CBD's Global Biodiversity Outlook 2 (2006); UNEP's Global Environment Outlook 4 (2007), and recently, PBL has been invited to contribute to the meeting of the Club of Rome (2009). The main topics concern sustainable development, the role of environment in reaching the Millennium Development Goals, climate change consequences and adaptation, and the role of biodiversity in development, and, in particular, poverty reduction. PBL contributes with information to improve the quality of policy-making by way of assessing future impacts of development on the environment, nature and spatial planning.

Poverty alleviation and biodiversity conservation are heavily linked, but the relationship is not well understood. To contribute to a theory on the complex relationship between poverty and biodiversity, we have responded to the request of the Directorate General for international Cooperation (DGIS) of the Ministry of Foreign Affairs, by carrying out an explorative research on the basis of 11 in-depth case studies with research and policy counterparts in developing countries.

This study indicates that two intervals exist: biodiversity is being lost while human well-being is improved and poverty is initially reduced, and secondly, biodiversity loss is reaching a critical value whereby production drops and human well-being and poverty are both affected negatively. The first interval appears in non-vulnerable ecosystems, the second one in 'brittle' ecosystems where poverty is often concentrated.

What do these – simplified – mechanisms imply for socio-economic development policies? Focus aid on the poor, subsistence-based natural-resource users, in a situation with high biodiversity loss and relatively low production, or focus on modern, market-oriented production systems without guarantees of benefits for the poor, or do a bit of both? The world is desperately waiting for evidence-based answers.

These insights offer challenges at the national and international policy levels. We hope that this document will prove to be a source of inspiration for a dialogue between DGIS, other ministries, international environmental organisations, international conventions and research institutes. We thank all our partners for their contributions to this research.

Director, Netherlands Environmental Assessment Agency

Prof. dr. M.A. Hajer

Contents

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We owe many thanks to the members of the Brainstorming Group who provided us with useful ideas and feedback: Wijnand van IJssel (chairman), Antje van Driel, Ron Havinga, Leontine Crisson, Peter Bos, Arthur Eijs, Chris Enthoven, Paul Wolvekamp and Willy Douma. They had the courage to join us in our search for patterns and systematisation in a complex field. They spent time and energy discussing the research with an open mind and a constructive attitude, and shared knowledge, insights and views. Annex 6 lists the members of the Brainstorming Group and their organisations.

We thank our research partners in the developing countries who enthusiastically cooperated in discussing the significance and feasibility of the conceptual models, indicators and determinants, and who provided us with the valuable information recorded in the case studies. They organised interdisciplinary working groups and workshops and indefatigably helped us to solve problems and overcome setbacks. They also offered us opportunities to visit case areas and get a personal impression of the local situations. The contact people for the research groups and their organisations are listed in annex 5.

Jan Joost Kessler joined the project at an early stage. We highly value his professional contributions to all stages of the project. His experience, knowledge, ideas and views gave input to the kick-off of the case studies; he facilitated workshops, analysed cases, systematized the results of the case studies, wrote background reports and helped us tremendously in getting to grips on the conceptual framework, determinants, patterns and mechanisms of the relationship between poverty and biodiversity.

Tjark Struif Bontkes, Adriana Rios and Eric Goewie shared their knowledge and ideas, and wrote background reports.

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Finally, we thank Derek Middleton who did an excellent job editing the draft report and Marian Abels and Filip de Blois who did the same editing the figures.

Summary

Literature review, a conceptual framework and case studies

Can poverty be reduced while at the same time conserving biodiversity? Decision makers face this challenging question when exploring ways to achieve the Millennium Development Goals and the CBD targets on biodiversity conservation. The aim of this study was to build a theory on the relationship between biodiversity and poverty that explains developments under different conditions. We reviewed the literature on these relationships and on the causes of change in biodiversity and poverty, drafted a conceptual framework for this relationship and tested this framework against the results of eleven case studies at subnational scale in developing countries. These cases concern production systems based on the use of natural resources. We cooperated with research partners in these countries, who carried out the case studies and contributed to the overall analysis.

In the conceptual framework the resource use system is central. The actor in this system has access to natural and socioeconomic assets. The resource use system causes changes in biodiversity, goods production, human well-being and poverty. These outcomes feed back into the natural and socioeconomic systems. This conceptual framework was used to define input indicators that characterise the state of the system. Outcome indicators were defined to characterise the changes in biodiversity, goods production, human well-being and poverty. The research partners analysed the cases and gave semi-quantitative scores to the input indicators. They also gave scores to the direction of change of the outcome indicators during the research period, which are favourable, neutral or unfavourable.

Serveral biodiversity-poverty relations found

In both the literature and the case studies, increasing and declining poverty levels coincided with an increase or decline in biodiversity in all possible combinations. We also found shifts in the direction of this relationship over time within the same resource use system. If we unravel the relationship between biodiversity and poverty in 1) the biodiversity–goods production and 2) the goods production–poverty dynamics, we find that:

1) A decline in biodiversity goes together with an increase in goods production and vice versa. Exceptions are cases where pressure put on the ecosystem for the production of goods exceeds the carrying capacity of the ecosystem. If the pressure continues, a decline in biodiversity goes together with stagnation or decline in production.

2) The relationship between goods production and poverty is less uniform. An increase in goods production does not automatically lead to better human well-being and poverty reduction. In several cases the profits made from production were taken out of the case area, population growth meant that the profits had to be shared between more people, or inequality led to the exclusion of certain groups from the means of production and income. There were also instances in which human well-being and poverty improved more than could be expected from the production of goods. This could be explained by emigration of poor people from the case area, policy interventions like subsidies, or a delayed reaction at the threshold of a turning point. In the latter case poverty still reduced, but production stagnated because expansion of the production area was halted at the boundaries of protected areas.

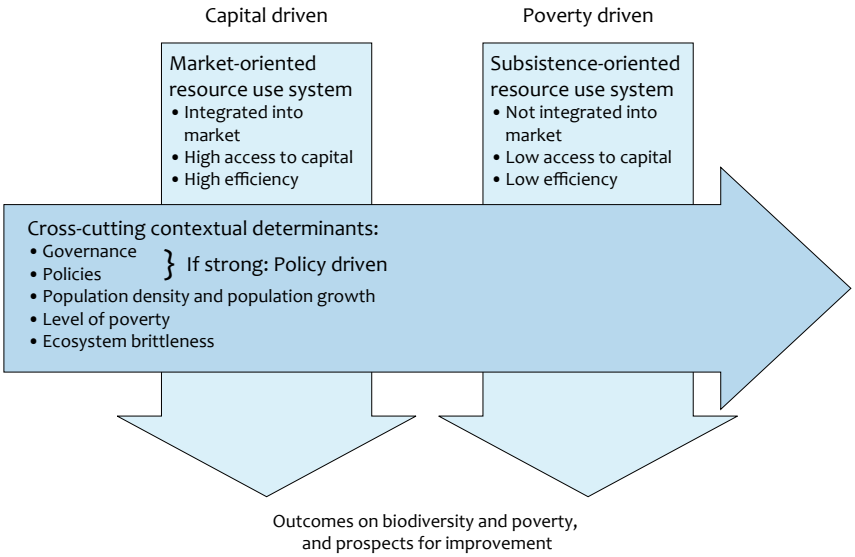
None of the cases is completely isolated. Goods, money, people and knowledge may cross the boundaries of the case area, generating trade-off effects that transcend the boundaries of the case areas and the time periods investigated. These trade-off effects change the relationship between poverty and biodiversity.

Mechanisms of change by analysis of determinants

After the data on all the eleven cases were brought together, 16 of the 34 input indicators were selected that were relevant for most cases and that reflected well the causes of change that were found in the literature and in the case studies. Some input indicators were dropped for practical reasons, such as a lack of data or ambiguous interpretations. On the basis of these 16 ‘determinants’, the eleven cases were divided into four groups:

1. Resource use systems with high access to capital that produce for the international market, which leads to strong biodiversity loss accompanied by improvement or stagnation in poverty levels: win – lose or neutral – lose trends for changes in respectively poverty and biodiversity.
2. Resource use systems with low market integration, a high initial poverty level and fast population growth, in which an increase in poverty is accompanied by loss or stagnation of biodiversity: lose – lose or lose – neutral trends.
3. Resource use systems with limited access to capital and low market integration, high population densities and brittle ecosystems, in which a decrease or stagnation in poverty is accompanied by loss of biodiversity: win – lose or neutral – lose trends. These cases tend towards a com-

Characteristics of the major mechanisms of change **Figure S.1**



Major mechanisms of change are the drivers capital, poverty and policy.

bination of increasing poverty and decreasing biodiversity as found in group 2.

4. One resource use system with strong government interference and a relatively low poverty level, in which a decrease in poverty is accompanied by an increase in biodiversity: a win-win trend.

Market integration, access to capital, management skills and productivity are determinants that divide the cases into two broad groups: *market-oriented* resource use systems that are *capital driven*, with high scores for these determinants; and *subsistence-oriented* resource use systems that are *poverty driven*, with low scores for these determinants (*Figure S.1*). Market integration offers opportunities for generating income and reducing poverty. Whether this leads to actual poverty reduction depends on cross-cutting determinants, which are associated with the socioeconomic context of the resource use system. The determinants are: governance, policies on poverty and biodiversity protection, and population density and growth. Strong governance and policy interventions may shift negative poverty and biodiversity trends in a more positive direction, but they may also cause dependency on government support. These resource use systems are *policy driven*. Weak governance and policies in capital-driven systems may lead to high biodiversity loss without poverty reduction. Although they are in principle transitory and subjective in nature, we think that the three contrastive mechanisms can easily be observed in practice. This typology may simplify diagnosis for intervention strategies. These insights can be used to set up future case studies and help research teams map existing situations by scoring the selected determinants.

The basic pattern explaind

The 'brittleness' of the ecosystem (vulnerability for overexploitation and ability to recover or self-regenerate) is an important cross-cutting factor too. If natural resources are abundant and brittle in capital-driven systems, this leads to strong expansion of production and a vast loss of biodiversity. In poverty-driven systems, fast population growth and little management input may have the same effect. If the limits of expansion are reached, either production is intensified, with the risk of overexploitation if ecosystems are brittle, or people and production leave the area.

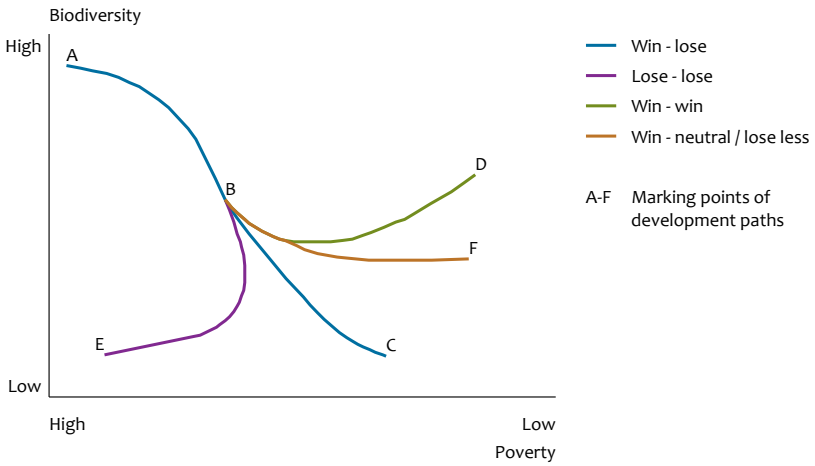
We assume that all resource use systems follow a limited set of basic patterns of change in biodiversity and poverty *(Figure S.2)*. These may differ in absolute values and in the ratio of change, but in essence follow the same courses. Hypothetical courses are:

- A decrease in poverty combined with a decrease in biodiversity (win-lose, A > C): production at the cost of biodiversity generates income that improves human well-being and reduces poverty.
- A decrease in poverty combined with an increase in or conservation of biodiversity (win-win/neutral, B > D/F): biodiversity recovers while human well-being improves because society can afford measures and technology to simultaneously improve production and save biodiversity.
- An increase in poverty combined with a decrease in biodiversity (lose-lose, B > E): exploitation leads to degradation of the natural system and productivity declines; population growth and inequality maintain poverty.

Variation of the position of this graph along the axis of biodiversity is caused by the brittleness of the ecosystem. The variation along the axis of poverty is caused by the vulnerability of the socioeconomic system. Together they influence productivity, profitability, population density and equality.

There are reasons to assume that a 'green Kuznets curve' –reduce poverty while recovering biodiversity- does not exist if all trade-off effects are considered. Technical measures hardly reduce the impact on biodiversity caused by commodities, such as food, fibre and fish. In essence, humans are in direct competition with their fellow creatures for

Hypothetical courses of biodiversity and poverty **Figure S.2**



Hypothetical 'prototype' courses of change in biodiversity and poverty.

space, energy, minerals, matter and water. This fundamental competition cannot be removed by technical solutions. Only when the efficiency of resource use systems is suboptimal, so that resources are spoiled or wasted, is it possible to develop a pathway where an increase in goods production and the restoration of biodiversity go together.

Further research to consolidate the findings of this study should focus on the following main areas of study:

- Verification of determinant patterns, mechanisms and biodiversity–poverty courses in other cases.
- Quantification of the relationship between goods production, ecosystem services and biodiversity loss for varying production systems and ecosystems.
- Investigation of the relationship between poverty in rural and urban areas, and trade-off effects between areas at different scales.
- Other mechanisms of change, for example conflicts and the impact of climate change.
- The impact of policy interventions in different circumstances, typified by the determinants and mechanisms.

1 Introduction

The Netherlands Environmental Assessment Agency has studied the relationship between biodiversity and poverty as part of the International Biodiversity project, which ran from 2005 to 2008. This study investigated natural-resource-based livelihoods that are connected to land or water: agriculture, aquaculture, forestry, reforestation, fishery and gathering. The analysis was performed from the point of view of biodiversity. The report is based on eleven case studies at subnational scale that were carried out in eight developing countries. The Netherlands Environmental Assessment Agency cooperated on this with research partners at local research institutes, governmental organisations and NGOs, who carried out the case studies and contributed to the overall analysis. The case studies were on fisheries in Ghana and Kenya, mangrove exploitation in Vietnam, forest use, reforestation and forestry in Vietnam and Costa Rica, soy in Brazil, palm oil in Indonesia, peasant agriculture in Ecuador and Mexico, livestock production in Nicaragua and cotton in Mali.

The aim of this study was twofold:
1. To build a theory on the relationship between biodiversity and poverty that explains developments under different conditions. The study contributes to the debate as it reviews the literature, drafts a conceptual framework and tests this framework against the results of case studies.
2. To build a joint knowledge base on the relationship between biodiversity and poverty with our research partners.

The study set out to answer three research questions:
1. How are biodiversity and poverty related under different conditions?
2. What indicators and what values of these indicators determine this relationship?
3. What mechanisms explain this relationship and indicator values?

Can poverty be reduced while simultaneously conserving biodiversity? This is the challenge facing decision makers when exploring ways to achieve the Millennium Development Goals (MDGs) and the targets stated in the Convention on Biological Diversity (CBD). In 2000 the United Nations endorsed the MDGs of halving the population suffering from poverty and hunger by 2015 (MDG1) and ensuring environmental sustainability (MDG7). The sixth Conference of the Parties to the CBD decided 'to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global and regional level as a contribution to poverty alleviation and to the benefit of all life on Earth'. This was reconfirmed by the World Summit in Johannesburg, 2002. Many countries, including the Netherlands, have adopted policies on poverty reduction and on the conservation and sustainable use of biodiversity.

Planning and implementing such policies at the global and local scales requires a better understanding of the relationship between poverty reduction and biodiversity conservation, as these relationships are complex, context-specific and depend on spatial scale and temporal horizon. Local people, especially the poor, depend directly on natural resources for their livelihoods and suffer disproportionately from biodiversity depletion. Policy makers urgently need a better understanding of these relationships in order to implement cost-effective development policies and formulate policies to avoid poverty resulting from biodiversity loss, reduce poverty without biodiversity loss, and restore biodiversity to help reduce poverty.

The relationship between biodiversity and poverty is a key topic in the Global Environmental Outlooks (UNEP, 2002 and 2007b), the second Global Biodiversity Outlook (UNEP-CBD, 2006) and the Millennium Ecosystem Assessment (MEA, 2005a) but is hardly quantified.

This report is a discussion paper. It therefore ends with probable explanations for the observed phenomena and suggestions for further research. It aims to bring the conceptual thinking and theory on the relationship between biodiversity and poverty one step further by empirically testing concepts from the literature.

Chapter 2 explores the relationship between poverty and biodiversity in a review of the scientific literature, global assessments and conventions. Drawing on the review, we develop a conceptual framework and a methodology for the case studies in Chapter 3. The 11 case studies are described in Chapter 4. Determinants and patterns that explain the combined impact on poverty and biodiversity, and mechanisms of change, are identified in Chapter 5. Chapter 6 contains the findings, conclusions and further reflections. This chapter ends with recommendations on further research.

2 Findings from the literature

A basis for the conceptual model and hypothesis for this study was obtained by surveying the literature on the causes of changes in biodiversity and poverty (section 2.1) and on the relationship between biodiversity and poverty (section 2.2), as well as the recent Global Assessments (section 2.3) and global conventions on biodiversity and poverty (section 2.4). Section 2.5 contains some concluding remarks.

2.1 Causes of change in biodiversity and poverty

The literature describes many causes of change in biodiversity and poverty. These have been grouped into economic, production, social, political and ecological/environmental factors. Many causes are interdependent and mutually linked. No sources were found that gave quantified cause-effect relations.

2.1.1 Economic factors

Economic causes can be subdivided into economic growth, market integration and competition.

Economic growth is an indispensable condition for poverty alleviation, not a guarantee (Stiglitz, 2003; Collier, 2007). The 'trickle down' effect is not an autonomous process, but needs institutional arrangements. Indeed, various authors found no significant relation between economic growth and improved livelihoods of the poor (UNCTAD, 2002; UNCTAD, 2004 in: Kessler and Abaza, 2006). For example, small farmers are often excluded from the agro-export boom, which may lead to higher food prices and less food security, or they suffer from the effects of environmental degradation (Kirkpatrick and Lee, 2001). Global actors strongly influence the exploitation of export commodities (Kessler et al., 2001).

Economic crisis is frequently mentioned as a factor causing deforestation and biodiversity loss, because impoverished people fall back on natural ecosystem exploitation as a safety net (Lambin et al., 2001). Resource collapse and price collapse can both result in increasing exploitation and further resource degradation.

Market growth and global market integration are important factors affecting biodiversity (Geist and Lambin, 2003). Market failures, monopolies and unstable prices affect the socioeconomic conditions of the production sectors (Contreras and Hermosilla, 2000). Trade liberalisation does not automatically lead to economic growth (Kessler and Abaza, 2006) and in the least developed countries may even lead to the opposite (Stiglitz, 2002). Openness to trade does not automatically lead to increased trade (Kessler and Abaza, 2006) and export growth does not always significantly reduce poverty (Kessler et al., 2007).

Competition affects the distribution of wealth and poverty. The first producers to adopt a new high-profit technology become winners; the late developers are out-competed and become losers (the treadmill) (Röling, 2000; FAO, 2002; Collier, 2007). The economies of the least developed countries are based on natural resources and not technology. As Southern countries have limited power and leverage, growth in the export sector depresses the prices of primary commodities (Muradian and Martinez-Alier, 2001). To cope with declining income, these countries increase production by increasing the cultivated area, and by mechanising and intensifying production, which again results in lower prices, and so on.

2.1.2 Production factors

Production factors comprise access to natural resources and ecosystem productivity, management skills and technology, and economic return.

Crop or livestock development depends in the first place on *access to natural resources* and *ecosystem productivity* (Hopfenberg and Pimentel, 2001; de Vries and Goudsblom, 2002; Kessler et al., 2007). Agricultural systems provide 10–1000 times more food than natural ecosystems (Diamond, 1999), but depend on the services provided by biodiversity as well as the supply of inputs (Angelsen and Wunder, 2003; Kessler and Van Dorp, 1998 in: Kessler and Abaza, 2006) and the genetic traits of crops and livestock (FAO, 2007; Fowler et al., 1990; Jarvis and Hodgkin, 2000). Higher productivity is attained through external inputs, *management skills and technology*. Mechanisation and intensification (Boserup, 1965) have been able to compensate for the Malthusian repercussions of increasing population pressure (Malthus, 1798), but Malthusian and Boserupian processes are not opposing forces; they tend to coexist (Demont et al., 2007). Malthus' theory that the size and growth of the population depend on the food supply and agricultural methods is supplemented rather than negated

by Boserup's theory that agricultural methods depend on the size of the population. Malthus stated that in times when food production is not sufficient to feed the whole population, some people will die. Boserup stated that in these times people will find ways to increase productivity by making use of the increasing workforce, machinery, fertilisers, etc. However, technological progress has not banished hunger from the world because the global population has continued to grow and the benefits of technological progress are not equally distributed (Koziell and Saunders, 2001; Wright, 2005).

Biodiversity loss increases as the intensity of exploitation increases (Kessler, 2003; Alkemade et al., 2006). *Economic return* depends on productivity, cost advantages and market integration (Lambin et al., 2001; Kessler et al., 2007). The poverty rate is highest not only in areas of high population density and degraded natural resources (Dixon et al. 2001), but also in remote areas where population density is low and forests still remain intact (Müller et al., 2006).

There is no solid evidence that participatory forest management practices contribute to poverty reduction (Fisher, 2007). Forests are safety nets in time of crisis, gap fillers for communities with structurally low incomes from other activities, or permanent sources of income that lift people out of poverty (Cavendish 1999 and 2003). Small to medium-sized forestry enterprises can reduce poverty, whereas industrial forestry can at best protect communities against worsening poverty, but hardly reduce poverty levels (Mayers, 2007; Wardle, 2003). Forest dwelling may be a poverty trap rather than a safety net (Kessler, 2005). It has limited potential for poverty reduction because it is difficult to obtain a high income from non-timber forest products from the commons (Kessler, 2005).

2.1.3 Social factors

The social factors are broken down into distribution of wealth or power, historical poverty, demographic changes and socio-cultural dilemmas.

In essence poverty is the result of an unequal *distribution of food and economic and political power* (Millennium Project, 2004a; Millennium Project, 2004b; Contreras and Hermosilla, 2000), but it is also linked to environmental conditions. Poor nutrition (stunting), for example, is most frequently found in areas of high soil degradation (Potting and Bakkes, 2004). However, according to Woodhouse (2002) unequal income distribution, and consequently (relative) poverty, exists everywhere, independent of ecosystem features and food supply. Inequality arises as an autonomous process, even from situations in which people have an equal start, and is driven by differences in the physical conditions of land and property, differences in skill levels and just bad luck (sickness, hail, conflict, etc.). Poverty can also be the result of differences in the roles and rights of men and women, both within households and in the community at large. Women are frequently highly vulnerable to changes in ecosystem services.

Rich and powerful people often take possession of the commons (forest, rangelands), the exploitation rights of which historically belong to local peoples (Raswant et al., 2008; Woodhouse, 2002). This is referred to as the privatisation of natural resources (Kessler, 2005) or the enclosure movement (Beresford, 1998). Formal or informal income-redistribution systems counteract this phenomenon.

Past or present poverty in itself has a powerful influence on the level of future impacts on biodiversity and poverty (IFAD, 2001) as people become trapped in a cycle of poverty (Collier, 2007). Indebtedness (Geist and Lambin, 2003) is an important cause of deforestation.

Recent *population growth* has been exponential and unprecedented (Klein Goldewijk, 2005), while resources are limited. Demographic dynamics (population density and growth, immigration and emigration) is a key issue related to poverty at the local scale (Contreras and Hermosilla, 2000; Geist and Lambin, 2003).

People are proud of their *culture and livelihoods* and prefer to be independent and self-sufficient. Respect, self-respect and social acceptance are basic human needs (Maslow, 1943) and basic social and cultural needs should be part of the solution to poverty. Although there is sufficient food to feed the world's population – the number of overweight people exceeds the number of undernourished people – just redistributing goods from the rich to the poor is not the whole answer.

2.1.4 Political factors

Policies were identified on markets, land, production, the environment and social security. Governance and conflict also play an important role.

While *free market policies* do support national economies (UNCTAD in: Kessler et al., 2007), they can have both positive and negative impacts on environmental sustainability, depending on incentives and regulations (Van den Berg and Verbruggen, 1999). The effects of trade policies depend on many contextual factors and the way they are implemented (Kirkpatrick and Lee 2001); there is no one-to-one relationship between policies, measures, production changes, poverty and environment. Young, upcoming economies are fragile and need to be protected against strong economies, which justify economic protection measures in the early stages to avoid poverty (Stiglitz et al., 2002; Collier, 2007).

Land policies (Geist and Lambin, 2003), *agricultural expansion policies and intensification policies* (Kessler, 2005) may help to maintain or increase productivity and improve the incomes of natural resource users. However, perverse policies (Contreras and Hermosilla, 2000) may increase inequality in the rural population or promote activities that lead to biodiversity loss (Mayers, 2007). Pauly et al. (1998) elaborates on perverse subsidies to global fisheries that induce the depletion of entire fish stocks. Payments for environmental services (Ibarra, 2007), avoided deforestation (Griffiths, 2007) and biodiversity protection may counteract biodiversity loss.

Massive *food aid* has also created negative side effects. Communities have become more and more dependent on aid, which leads to a loss of pride and livelihoods, and even the collapse of some local agricultural economies. From a long-term perspective, food aid may not reduce poverty, but actu-

ally worsen it (King, 2005). It may keep the recipients alive and allow the population to grow, but does not enabled them to solve the problem structurally. This problem will become worse if Official Development Aid for poverty reduction and biodiversity protection (~0.7% GDP) is not fully invested in structural solutions (Collier, 2007).

Government weaknesses (Contreras and Hermosilla, 2000), corruption and mismanagement (Geist and Lambin 2003), and failure to update and enforce legislation (Kessler et al., 2001) are some of the *governance* factors that put a burden on poverty reduction and biodiversity protection. NGOs can play a significant role in improving governance by monitoring and evaluating policies and government performance (Kessler et al., 2001).

Civil war and rebellion may be explained by atypical grievances, such as high inequality, hunger (Messer et al., 2001), lack of political rights or ethnic and religious divisions in society (World Bank, 2003). Low GDP and low income countries are most vulnerable to civil war (Collier and Hoeffler, 2004). Civil war has a negative impact on GDP, income and income distribution, poverty, social security, education, public health and foreign investments, and it encourages emigration and the associated loss of intellectual and financial capital, reducing the chances of economic development (Contreras and Hermosilla, 2000; Collier, 2007). According to Heinsohn (2003), it is not high population density itself that sparks off conflict, but population growth leading to a youth bulge (more than 30% of the population younger than 14 years).

2.1.5 Ecological/environmental factors

Ecosystem stability, brittleness, exploitation and regime shifts were identified as ecological factors.

Most natural *ecosystems arefairly stable*. This equilibrium is maintained by a wide diversity of organisms pursuing different life strategies and inhabiting different niches, exploiting available flows of materials and energy (Naeem et al., 1995).

Ecosystem *exploitation* may cause resource degradation (Oldeman et al., 1990), but not all natural ecosystems react to disturbance in the same way. Ecosystems can be classified according to their *brittleness*: the ability to recover or self-regenerate (Savory, 2000). Non-brittle ecosystems are able to self-regenerate following exploitation, while brittle ecosystems do not. Non-brittle ecosystems are generally characterised by higher levels of rainfall and humidity, high fertility and a low chance of erosion. Brittle ecosystems are the opposite; they degrade after human use owing to the persistent leakage of the key elements of ecosystem productivity: nutrients, water, energy, minerals and species (Foley et al., 2005; Haberl et al., 2007; UNEPa, 2007; WRI, 1998; Pauly et al., 1998; Alkemade et al., 2006). The extent of this leakage depends on the intensity and extent of the human activities as well as the sensitivity of the ecosystem to pressure and its resilience. Resilience is the long-term adaptive property of the system to withstand external perturbations without changing its basic structure (based on Gunderson et al., 1995).

Ecosystem services such as carbon sequestration, water holding capacity, soil fertility, soil stability and organic matter decomposition may decrease after human exploitation or management of the ecosystem that is geared towards maximising the production of a single good at the expense of others (MEA, 2005a). Research on testing community and ecosystem function in situations where biodiversity is still high is complex and results have been inconsistent (Thompson and Starzomski, 2007). The consequences of the loss of biodiversity for ecosystem functioning depend on the scale of analysis. Dominant species are often the major contributors to ecosystem goods and services.

Although most natural systems change gradually under human use, dramatic *regime shifts* are observed too (Scheffer et al., 2001). Reversing such a shift is often difficult or even impossible, due to positive feedback mechanisms. Examples are the response of shallow lakes to eutrophication, grasslands to grazing pressure, populations to habitat fragmentation, marine systems to fishing pressure, coral reefs to land erosion and overfishing (Gunderson and Pritchard, 2002; Van Nes and Scheffer, 2004). As the level of exploitation or pollution loads increase, systems may slowly lose their resilience without this being noticed. Once the threshold is – unexpectedly – passed, the system collapses. It is difficult to predict the threshold level.

2.2 Relationships between biodiversity and poverty

Four main types of relationship between changes in biodiversity and changes in poverty have been described:

1. Win–lose: a decline in poverty is accompanied by a decline in biodiversity
2. Lose–lose: an increase in poverty is accompanied by a decline in biodiversity
3. Win–win: a decline in poverty is accompanied by an increase in biodiversity
4. Win more–lose less: a decline in poverty is accompanied by biodiversity conservation policies

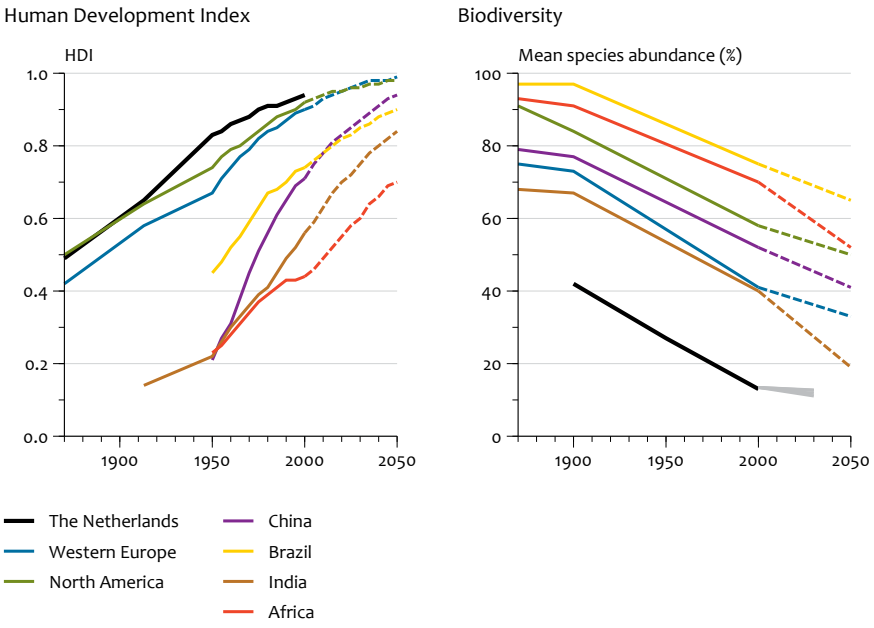
Win–lose

The most frequently mentioned relationship is a win–lose trend: a decrease in poverty and increase in human well-being at the expense of biodiversity. Drawing on the results of many scientific studies worldwide, the MEA (2005a) states that changes in ecosystems have led to substantial benefits, especially in food supply and to industries based on the use of natural resources:

- Food production has more than doubled since 1960.
- Food production per capita has grown.
- Food prices have fallen.
- The agricultural labour force accounts for 22% of the world's population and half the world's total labour force.
- Agriculture accounts for 24% of GDP in low-income developing countries.
- The market value of ecosystem-service industries is about $980 billion per year for food, $400 billion for timber, $80 billion for capture fisheries and $57 billion for marine aquaculture. For recreational hunting and fishing it is more than $75 billion per year in the United States alone.

According to the Second Sustainability Outlook by the Netherlands Environmental Assessment Agency (MNP, 2008),

Human Development Index and biodiversity **Figure 2.1**



The Human Development Index (HDI) and biodiversity ('Mean Species Abundance', MSA) are inversely related (MNP, 2008, adapted).

biodiversity and human development show inverse trends at global, regional and national scales (*Figure 2.1*).

According to Boserup (1965) production increment is attained first by expanding the crop area and subsequently by intensifying production when no additional land is available to bring into cultivation. Both these processes lead to biodiversity loss. The Millennium Environmental Assessment (MEA, 2005b) concludes that the production capability of agricultural systems is undermined by soil erosion, salinisation and loss of agricultural biodiversity. Their effects on food production are masked by increasing use of fertilisers, water and other agricultural inputs. A win–lose situation today may turn into a lose–lose situation tomorrow.

Economic growth can have trade-off effects on biodiversity elsewhere. For example, downstream biodiversity and livelihoods along the Mekong River are threatened by the upstream improvement of navigation, economic corridor development and hydropower development (Lazarus et al., 2006).

Lose–lose

Many cases of increased poverty resulting from biodiversity or ecosystem degradation have been described. Coral degradation in the Caribbean has a negative impact on coastal communities, including the loss of fishing livelihoods (UNEP, 2007b). In a ten-year period, 26 commercial fisheries in the Black Sea were destroyed (Shiganova and Vadim, 2002 in: UNEP 2007a). Agricultural land suffers from invasive weeds, such as alang-alang (*Imperata cylindrica*) in Indonesia and prickly pear cactus (*Opuntia ficus-indica*) in South Africa (CSIR, 2008).

Arid and semi-arid lands are brittle to human exploitation (MEA, 2005b). They are relatively densely populated in relation to their productive capacity and 10–20% of the land used for agricultural production in arid and semi-arid areas is degraded. People living in these areas suffer from decreasing productivity of livestock and arable farming (Sanchez, 2002). Infant mortality rates[1] are high. Forested areas have declined dramatically in many countries, but 350 million people still depend primarily on local forest for their subsistence and survival (MEA, 2005b).

The poor suffer disproportionately from increasing environmental degradation and are particularly susceptible to the impact of natural disasters. The poor identify security as a key concern (DFID, 2000; DFID, EU, UNDP and World Bank, 2002).

The turning point from win–lose to lose–lose

The win–lose trend may turn into a lose–lose trend. Exploiting specific goods and services generally causes a chain of ecosystem reactions, which in turn may cause the supply of goods to decrease (MEA, 2005b):

- The capacity of ecosystems to buffer extreme events has been reduced through loss of wetlands, forests, mangroves.
- People increasingly occupy regions exposed to extreme events.
- Many services are related to specific biodiversity components. Degradation leads to the loss of non-marketed benefits from ecosystems. The economic value of these benefits is often high and sometimes higher than the marketed benefits.

1 See glossary, Annex 4.

Unsustainable use causes the depletion of the living and non-living components of the natural world. There are several examples in history linking the degradation of natural resources to the collapse of whole societies (e.g. Mayas, Vikings and Anasazi) (Wright, 2005; Diamond, 2004). However, Diamond (2004) concludes that no known collapse of a culture can be attributed solely to environmental degradation. Other factors were also involved: climate change, hostile neighbours and the ability to respond to environmental problems. Ecosystem degradation can rarely be reversed without actions that address one or more indirect drivers of change:

- population change (including growth and migration);
- change in economic activity (including economic growth, disparities in wealth, and trade patterns);
- sociopolitical factors (including factors ranging from the presence of conflict to public participation in decision-making);
- cultural factors;
- technological change.

The turning point from win–lose to win–win

The dominant focus in development policies is economic growth at the expense of the environment, while solving environmental problems which arise as a result is postponed to a later stage (Van Bodegom et al., 2006). Although certain minimum environmental standards are suggested, making a choice between environment and development is seen as inevitable. It is also argued that increasing human well-being and economic growth may drive the development of environmental legislation and improve environmental quality in the future. This is called the environmental Kuznets curve (EKC) (Grossman and Krueger 1995; Yandle et al., 2004 in: Kessler et al., 2007).

It is still debated whether environmental restoration (the 'grey Kuznets curve') leads to biodiversity restoration as well, the 'green Kuznets curve'. According to McPherson and Nieswiadomy (2005), a green Kuznets curve exists for mammals and birds. The percentage of threatened species rises as income per capita increases from US$12,000 to US$14,000 per year. At higher levels, the percentage of threatened species falls. According to Kahuthu (2006), there is significant evidence of an EKC-type relationship between income per capita and CO_2 emissions across countries. The turning point is far beyond the income level of middle- and low-income countries. As a consequence, it will take developing countries a few decades to reach the EKC turning point. In contrast, forest cover shows no such turning point. Kahuthu found that higher global market integration corresponded with faster deforestation. Gutman (2008) states that critics argue that the 'get rich first and clean up later approach' (the 'Kuznets curve argument') has seldom worked for rural areas and will never work where irreplaceable natural assets are concerned, with the attendant risks of species extinction, desertification and large landscape level transformations.

Local win–win and impacts elsewhere

If maps of poverty and biodiversity are overlaid, all combinations of low–high biodiversity with low–high poverty occur. This is true at the national and global scales and can be explained by trade-off effects that disturb the picture. Economic growth and biodiversity restoration in one place may cause biodiversity loss elsewhere: the ecological footprint (Wackernagel and Rees, 1996; Wackernagel et al., 2002; Rood and Alkemade 2005; Kessler et al., 2007). Ecological footprints may or may not be situated in poor areas. Rich countries and rich people have a larger footprint than poor countries and poor people (Wackernagel et al., 2006).

Local win–win under pro-poor and pro-conservation policies

Natural resources can provide the basis for improving livelihoods. At the World Parks Congress in 2003 Wildlife Conservation Society developed 'people-centred conservation', 'pro-poor conservation' and other strategies based on the following principles (Adams et al., 2004; Van Bodegom et al., 2006):

- Use poverty reduction as a tool for conservation.
- Compensate and mitigate the negative impacts of conservation on poor people.
- Adapt conservation to generate new benefits.
- Use conservation as a tool for poverty reduction.

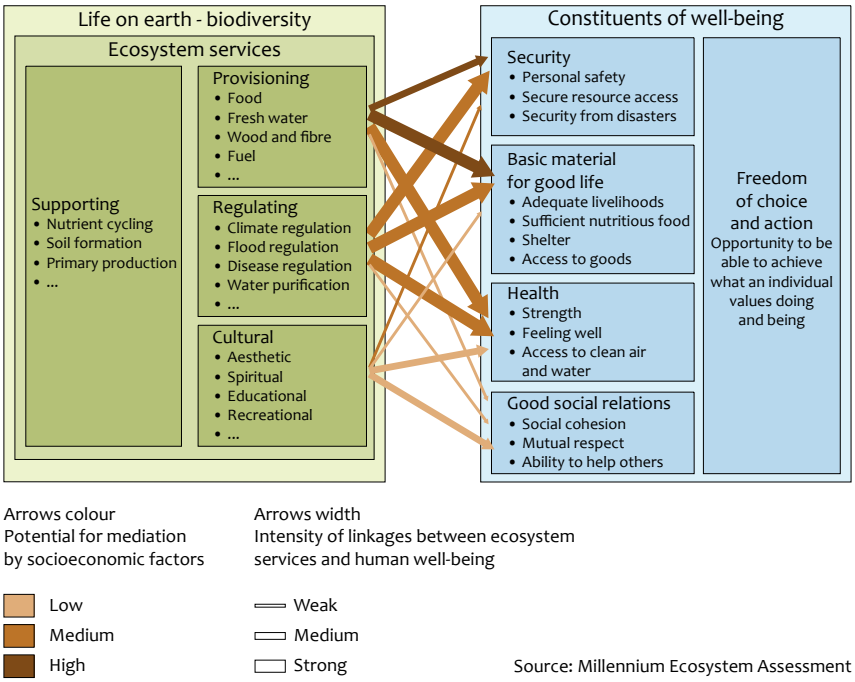
'The view on poverty alleviation and biodiversity conservation shifted in the last decades from separate or contradictable issues towards a "two sides of the same coin". To date a pragmatic ecosystem approach is followed in search for biodiversity conservation and simultaneous poverty alleviation', conclude Van Bodegom et al. (2006) and Reed (2006). There is a shift towards conservation by improving livelihoods, generating alternative livelihoods and compensation for lost benefits. This is because poor people are prepared to invest in the environment if they see tangible benefits and the potential for economic improvement. Emphasis is placed on working with the poor and on improving governance as new evidence challenges entrenched assumptions about poverty–environment interactions (DFID, 2000):

- The poor are too poor to invest in the environment. Although in some cases this is true, there is much evidence to show that when incentives are favourable, even the poor can mobilise enormous resources, particularly labour.
- The poor do not care about the environment. There are numerous examples to show poor people often place great value on the environment, both as a resource base and for cultural, aesthetic and religious reasons.
- Most environmental degradation is caused by the poor. Globally, most environmental degradation is caused by the non-poor, as the consumption levels of the poor are still low relative to the rich.
- Poverty reduction necessarily leads to environmental degradation. Studies have failed to show a common pattern in the linkage between poverty and resource use. The relationship between poverty and the environment is complex and requires context-specific analyses – there is no simple causal relationship. There is sufficient evidence to refute the statement 'poverty reduction and environmental concern are incompatible'.

Win more–lose less

Local Integrated Conservation and Development approaches offer win more–lose less solutions, as opposed to thinking in terms of win–win, win–lose and lose–lose combinations (Bodegom et al., 2006). Sustainable use of natural resources can only be attained if civil society is strengthened, poverty is reduced and policies are oriented to the conservation of

Linkages between ecosystem services and human well-being **Figure 2.2**



Ecosystem services and their links to human well-being (MEA, 2003).

natural resources. Ingredients for success are amenable local traditions, an appropriate mandate and adequate resources, effective enforcement, exceptional conservation interest and long-term commitment (Abbot et al., 2001). Fisher (2005) assumes that:

- many cases of community action to improve livelihoods have led to increased conservation (also Abbot et al. 2001);
- local action results in better conservation than any other realistic alternative, but does not lead to a perfect conservation outcome;
- institutional change at different levels is the basis for improved conservation and poverty reduction.

The general development policy of the Directorate-General for International Cooperation (DGIS) at the Dutch Ministry of Foreign Affairs reflects the new paradigm of combined development and conservation. This is also true for the biodiversity–poverty co-financing channel (TMF, *Thematisch Financierings Fonds*). Under the overarching goal of poverty reduction, DGIS is committed to safeguarding ecosystems that regulate the basic processes that make life on earth possible (DGIS 2003; DGIS, 2005 in: Bodegom et al., 2006). However, in the short term, poverty reduction will not always be compatible with ecological sustainability and there is no policy document which outlines how to achieve both biodiversity conservation and poverty reduction in projects and programmes. The degree of success depends largely on a conducive environment (Van Bodegom et al., 2006), in which:

- benefits from the ecosystem are higher than the cost of conservation and management;
- the legislative and policy framework is in place;
- land and resource rights are clear;
- power relations are supportive to conservation and resources can be defended against unsustainable exploitation.

2.3 Conclusions of global assessments

Global assessments have recently given new insights into biodiversity, ecosystem services and poverty, and conceptual frameworks have been developed for investigating how life on earth is linked to human well-being (*Figure 2.2*) (MEA, 2003).

The main message of the Millennium Ecosystem Assessment is that human well-being and progress towards sustainable development are vitally dependent upon improving the management of Earth's ecosystems to ensure their conservation and sustainable use. But at the same time it is observed that the capacity of many ecosystems is diminishing to meet the growing demands for ecosystem services such as food and water. Human actions during the last 50 years have altered ecosystems to an extent and degree unprecedented in human history. The consequences for human well-being have been mixed. Health and wealth have, on average, improved but the benefits are unequally distributed and further improvement may be limited by an insufficient supply of key ecosystem services' (MEA, 2005a). Approximately 60% of ecosystem services (15 of 24 identified services) are being degraded or used unsustainably (*Table 2.1*). The degradation of ecosystem services often causes significant harm to human well-being and represents a loss of the natural assets or wealth of a country. To date, 1.1 billion people survive on an income of less than $1 per day; 70% of them live in rural areas where they are highly dependent on ecosystem services. Inequality has increased over the past decade. During the 1990s, the Human Development Index score for 21 countries declined. Water scarcity affects roughly 1–2 billion people worldwide. Desertification affects millions of people.

15 out of 24 ecosystem services are being degraded or used unsustainably (MEA, 2005a) **Table 2.1**

	Service	Status
Food	*crops*	↑
	livestock	↑
	capture fisheries	↓
	aquaculture	↑
	wild foods	↓
Fibre	*timber*	+/-
	cotton, silk	+/-
	wood fuel	↓
Genetic resources		↓
Biochemicals, medicines		↓
Fresh water		↓

	Status
Regulating Services	
Air quality regulation	↓
Climate regulation – global	↑
Climate regulation – regional and local	↓
Water regulation	+/-
Erosion regulation	↓
Water purification and waste treatment	↓
Disease regulation	+/-
Pest regulation	↓
Pollination	↓
Natural hazard regulation	↓
Cultural Services	
Spiritual and religious values	↓
Aesthetic values	↓
Recreation and ecotourism	+/-

There is evidence that changes being made in ecosystems are increasing in a nonlinear way (including accelerating, abrupt and potentially irreversible changes), with important consequences for human well-being. An example is the collapse of the Atlantic cod stocks off the east coast of Newfoundland in 1992, which forced the closure of the fishery. The depleted stocks may not recover (MEA, 2005a). The degradation of ecosystem services could become significantly worse during the first half of this century and forms a barrier to achieving the Millennium Development Goals. The challenge of reversing the degradation of ecosystems while meeting increasing demands for their services can be partially met under some scenarios that the Millennium Ecosystem Assessment (MEA) has considered, but these involve significant changes in policies, institutions and practices that are not currently under way. Although many facts and figures are presented on biodiversity, goods and services and human well-being, they are not framed in a causal relationship at the local or global scale (MEA, 2005a).

In the second Global Biodiversity Outlook (UNEP-CBD, 2006) MEA's generic findings were confirmed, but the biodiversity–poverty relationship was not quantified:

- 'The services provided by healthy, bio-diverse ecosystems are the foundation for human well-being.'
- 'Biodiversity loss disrupts ecosystem functions, making ecosystems more vulnerable to shocks and disturbance, less resilient, and less able to supply humans with needed services.'
- 'The consequences of biodiversity loss and ecosystem disruption are often harshest for the rural poor.'
- 'Garnering the political will to halt ecosystem degradation will depend on clearly demonstrating to policy makers and society at large the full contribution made by ecosystems to poverty alleviation efforts and to national economic growth more generally.'
- 'Apart from nature's immediate usefulness to humankind, many would argue that every life form has an intrinsic right to exist.'

The background document of the second Global Biodiversity Outlook states that Sub-Saharan Africa is stuck in a poverty trap (CBD/MNP, 2007). Africa's extreme poverty leads to low saving rates and low domestic saving is not offset by high inflows of private foreign capital. The combination of a low domestic saving rate and a high population growth rate has led to stagnation in Africa's pattern of capital accumulation. This means that to a significant extent, Africa is living off its natural capital.

The Global Environmental Outlook 4 (GEO4) expresses the environment–development paradox: 'Development that contributes to human well-being depends on the environment while impact from development on the environment affects human well-being' (UNEP, 2007a). Choosing between conserving natural ecosystems and converting ecosystems for agriculture presents a dilemma: the total value of natural ecosystems may be higher for the society in the long term (EFTEC 2005), but ecosystem conversion has higher direct benefits for individual owners. The maximum sustainable yield (e.g. catch of fish) does not coincide with the maximum economic profit. Moreover, loss of wealth due to ecosystem degradation, resource depletion and non-market products is not reflected in traditional economic accounts. A country could fell its forests and deplete its fisheries, and this would be reflected as a positive gain in GDP without registering the corresponding decline in assets. Knowledge about these interlinkages should be used to facilitate the transition to sustainable development. Eradication of extreme poverty and hunger depends on sustainable agriculture, fisheries and forestry, which in turn relies on ecosystem services such as soil fertility and water. GEO4 concludes that investments in environmental management result in increased income for the rural poor and the benefits of early action outweigh the costs. The increased incidence of extreme weather due to climate change is affecting people as well as biodiversity.

Other authors have also emphasised the complexity of the relationship between biodiversity and poverty. Reed stressed the multi-actor, multi-domain and multi-scale dimensions in his 3xM approach (Reed, 2006).

Vulnerability of people to poverty depends on exposure to threats, sensitivity to impacts and the ability to cope or adapt

(UNEP, 2007b). Lack of services makes people vulnerable to environmental and socioeconomic changes. This must be seen in the context of patterns (archetypes) of poverty:

- International trade has increased incomes and reduced poverty, but the large-scale extraction of natural resources has led to hazardous wastes, environmental impacts and biodiversity loss.
- Conflict, violence and persecution force people to move to marginal ecological and economic areas. This is development in reverse and has also led to degradation of natural resources.
- Natural hazards due to climate change and ecosystem destruction have claimed 1.5 million lives over the last 20 years and affect more than 200 million people annually.

From these global patterns, GEO4 concludes that strong synergies exist between improving human well-being and reducing vulnerability from environmental, development and human rights perspectives. Environmental protection requires a strong focus on human well-being.

The World Resource Institute (WRI, 1998) concludes that 'ecosystems are – or can be – the wealth of the poor. Harvests from forests, fisheries and farm fields are a primary source of rural income, and a fall-back when other sources of employment falter. But programs to reduce poverty often fail to account for the important link between environment and the livelihoods of the rural poor. As a consequence, the full potential of ecosystems as a wealth-creating asset for the poor – not just a survival mechanism – has yet to be effectively tapped. Income from ecosystems – or "environmental income" – can act as a fundamental stepping-stone in the economic empowerment of the rural poor.' For this to happen, the poor must manage ecosystems so that they support stable productivity over time. Productive ecosystems are the basis of a sustainable income stream from nature, but to tap that income, the poor must be able to reap the benefits of their good stewardship. Unfortunately, the poor are rarely in such a position of power over natural resources because this is usually prevented by an array of governance failures: lack of legal ownership and access to ecosystems, political marginalisation and exclusion from the decisions that affect how these ecosystems are managed. Without addressing these failures, there is little chance of using the economic potential of ecosystems to reduce rural poverty.

2.4 Statements of global conventions

Global conventions contribute to the discussion by identifying problems, defining topics, setting goals and defining sustainable and unsustainable development (UNEP, 1992). In *Our Common Future* sustainable development is defined as 'development that meets the need of the present without compromising the ability of future generations to meet their own needs' (WCED, 1987). The goal of environmental sustainability is to minimise environmental degradation and halt and reverse the processes they lead to (Agenda 21). Environmental unsustainability is a situation in which the total sum of nature's resources is used up faster than it can be replenished. In September 2000, at the United Nations Millennium Summit, world leaders agreed to a set of time-bound and measurable goals and targets for combating poverty, hunger, disease, illiteracy, environmental degradation and discrimination against women: the *Millennium Declaration* (UN, 2000a; UN, 2000b). The goals are ends in themselves (Millennium Project, 2005) and linkages between the goals are not directly addressed. The goals for hunger and disease are part of human capital and the goal for environmental sustainability is part of natural capital. Poverty traps were identified as one of the four reasons for shortfalls in achieving the goals (Millennium Project, 2005) as countries may be too poor to invest in environmental management and poverty reduction.

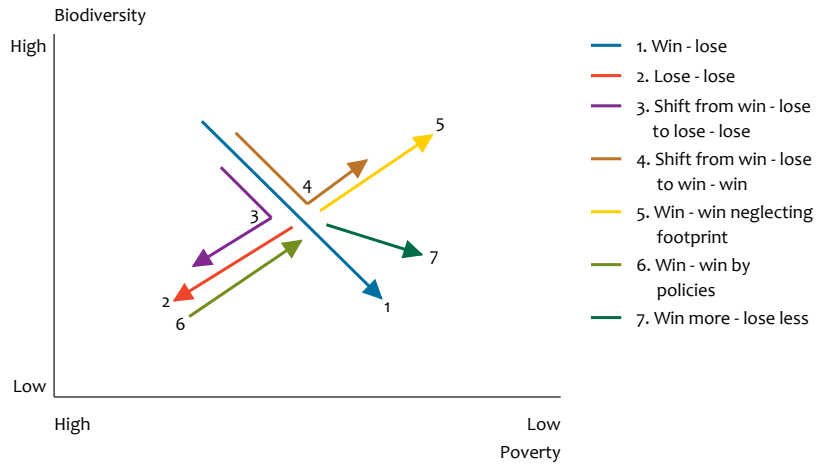
At the *World Summit on Sustainable Development* (WSSD, 2002; UN, 2002b) the United Nations recognised that eradicating poverty, changing consumption and production patterns and protecting and managing the natural resource base for economic and social development are overarching objectives of, and essential requirements for, sustainable development. World leaders declared that the 'deep fault line' between rich and poor posed a major threat to global prosperity and stability (UN, 2002a). The rapid integration of markets, mobility and capital and increased investment flows had created new opportunities, but the benefits and costs were unevenly distributed. 'We risk the entrenchment of these global disparities and unless we act in a manner that fundamentally changes their lives the poor of the world may lose confidence in their representatives and the democratic systems to which we remain committed. Biodiversity, which plays a critical role in overall sustainable development and poverty eradication, is essential to our planet, human well-being and to the livelihood and cultural integrity of people.' (WSSD, 2002; UNEP-CBD, 2002).

In April 2002, the Parties to the *Convention on Biological Diversity* (CBD) committed themselves 'to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation and to the benefit of all life on Earth' (UNEP, 2002). The CBD (UNEP-CBD, 2004) states that biodiversity is 'the foundation upon which human civilisation has been built. In addition to its intrinsic value, biodiversity provides goods and services that underpin sustainable development in many ways, thus contributing to poverty alleviation.' First, it supports the ecosystem functions essential for life on earth, such as the provisioning of fresh water, soil conservation and climate stability. Second, it provides products such as food, medicines and materials for industry. Finally, biodiversity is at the heart of many cultural values. In 2004, the Conference of Parties adopted seven focal areas and corresponding targets, goals and indicators in decision VII/30. Two of these focal areas relate biodiversity to human well-being: goal 4 on sustainable use and consumption and goal 8 on maintaining the capacity of ecosystems to deliver goods and services and support livelihoods (UNEP-CBD, 2004). It is, however, not clear at what level sustainable use must be set in order to avoid degradation of ecosystem integrity.

2.5 Concluding remarks

Our conclusions from this literature review are:

Findings of biodiversity - poverty connection from literature **Figure 2.3**



Different findings on how biodiversity and poverty relate.

1. Different combinations of trends in changes in poverty and biodiversity are found.
2. Biodiversity, poverty, ecosystem services and sustainable development are poorly defined concepts, and are often not quantified.
3. Different indicators, analytical frameworks, temporal and spatial scales and actor definitions are in use.
4. The relationship between biodiversity and poverty is a multi-domain, multi-scale and multi-actor issue.
5. The quantitative relationship between biodiversity and poverty under different conditions is hardly known.
6. An overarching and convincing theory is lacking.

The literature overview shows that there is agreement about the main drivers of socioeconomic development and changes in biodiversity, but no clear view exists on how biodiversity and poverty are related. The relationship between biodiversity and poverty differs from case to case, depending on specific conditions, the definitions used and the stage of socioeconomic development of the country or region in question. It is hard to find patterns in these conditions that will allow relationships to be explained and predicted by these conditions. Footprints and trade-offs have often not been taken into account and the losers and winners in the distribution of profits and wealth are not mentioned.

The following situations have been described (*Figure 2.3*):
1. Win–lose situations: socioeconomic growth can only happen at the cost of biodiversity.
2. Lose–lose situations: increase in poverty results from environmental degradation and biodiversity loss.
3. Win–lose situations turn into lose – lose situations.
4. Win–lose situations turn into win–win situations: described for environmental problems (Kuznets curve), but not for biodiversity.
5. Win–win situations at the local scale, neglecting the ecological footprint: these may in fact be win–lose (1) situations on a global scale.
6. Win–win by pro-poor and pro-conservation policies, combating lose–lose situations.
7. Win more–lose less: a pragmatic approach that is the motto in present development cooperation policies.

Global assessments show an increasing awareness of the dependence of humans on natural resources. The statements, findings and underlying assumptions contain much repetition ('mantra-like') and the conceptual frameworks of global assessments differ only slightly. However, underlying mechanisms are hardly quantified. This is especially important if concrete policy measures are to prevent biodiversity loss and reduce poverty in a cost-effective manner.

There are no references given for the scientific underpinning of the proclamations and assumptions in global conventions on biodiversity and poverty. It is therefore not clear whether it will be feasible to attain all the goals. The various goals have evolved from viewing biodiversity and poverty as separate topics into the vision that both are joint attributes of sustainable development, with increasing emphasis on the value of biodiversity for poverty reduction. Currently, the focus is on the importance of maintaining services derived from biodiversity to meet the growing needs of man.

Poverty, in essence, is an unequal distribution of food and economic and political power. Therefore, to discover more about the relationship between poverty reduction and ecosystem exploitation, it is essential to identify who profits from this exploitation, who misses the boat and who is affected by ecosystem degradation. These patterns may extend from the local to the global scale, as global actors dominate global markets. Policies on market liberalisation, agricultural expansion and food aid may have unintended side effects that work to maintain or even widen inequalities, worsen poverty and encourage ecosystem degradation. Structural solutions should incorporate the cultures and livelihoods of communities.

3 Developing a method

To answer the research questions, a case study approach with partner institutes from developing countries was adopted. The reasons for doing this are given in section 3.1 and the selection of cases is described in section 3.2.

The case study method and analytical method were developed with the research partners, sometimes in a process of trial and error. To start with, a conceptual framework was developed that combines the social and ecological aspects of the relationship between biodiversity and poverty. This was necessary to develop a shared vision as a platform for cooperation and research, to define relevant indicators and to structure data collection. Section 3.3 describes the framework used for analysis, which was based on two available frameworks from the literature, our own vision and the experience and opinions of our partners. The process of selecting indicators to fill in the conceptual framework is described in section 3.4.

The key concepts in this study are: biodiversity, goods and services, human well-being and poverty. These are concepts that decision makers will want to improve or influence, as they are commonly associated and linked with policy objectives such as the Millennium Development Goals (objectives on poverty reduction) and the CBD goals (objectives on biodiversity conservation). A multitude of definitions exist for these concepts, depending on the purpose for which they are used. The definitions used in this study relate to livelihoods that directly depend on natural resources. The selection of indicators for these concepts is described in section 3.5. Practice differed from theory, though, and our research partners deviated from the original proposed indicators owing to the availability of data and local or national customs.

The results from all the cases were analysed to identify general patterns and mechanisms. How this was done is described in section 3.6. Finally, the process of joint learning is described in section 3.7.

3.1 Why case studies?

We decided to use a case study approach because:

- it was feasible within the project time and budget constraints;
- it enabled in-depth studies by an interdisciplinary research team of environmental, social and economic characteristics in specific geographical areas and time periods;
- conceptual knowledge could be combined with knowledge from practice, and regional expertise improved the quality of the data, analysis and results;
- joint learning fits in well with the second goal of the International Biodiversity Project, capacity building, and benefits the partner countries and helps with testing the feasibility of indicators and models used by the Netherlands Environmental Assessment Agency.

We could not use the results from case studies already described in the literature, as in most of these cases the required information on poverty–biodiversity relationships was lacking or inconsistent, or measured on different scales, time periods or units, or because there was no clear conceptual framework for analysis. Many of these cases represent the scale of a development project and focus on the impact of project implementation (short-term impact and small-scale pilot sites) instead of historical development processes.

In view of these limitations, new case study research was carried out. The case studies had the following objectives:

- To acquire insight into the dynamics of the relationship between biodiversity and poverty
- To capture these insights in a set of indicators that allow a better understanding of the dynamics
- To extrapolate these findings to other cases

Strategic partners in the selected regions were contracted to carry out the research. For all cases, interdisciplinary teams were established. The teams consisted of members of governmental organisations, NGOs and sector organisations, who, as end users, specified key questions and expected results, and experts from local research institutes, universities or research-oriented NGOs. The expert was responsible for establishing interdisciplinary teams and stakeholder representatives, and was invited to attend international events to exchange methodology, results and ideas.

3.2 Selection of cases

The following criteria were used to select cases. The cases should:

- be in developing countries, if possible in the partner countries of the Netherlands Ministry of Foreign Affairs;
- cover three continents, for a broad spectrum of livelihoods and ecosystems;
- cover the full range of low and high biodiversity quality;

Cases investigated (the research teams are listed in Annex 5) Table 3.1

Case study country & region	Research team contact	Ecosystem	Sector	Theme
1. Brazil - Cerrado	AIDEnvironment	Savannah	Export-oriented commodity: soy	Forest conversion by soy expansion
2. Indonesia - Kalimantan	AIDEnvironment	Tropical forest	Export-oriented commodity: palm oil	Ecosystem conversion to palm oil development
3.Costa Rica - Hojancha	CATIE	Tropical forest	Forestry	Reforestation and payments for environmental services
4. Ecuador - Cotopaxi	Ecociencia	Mountain	Crop and livestock	Smallholder farming
5. Ghana - Coast	UBC	Marine	Fishery	Subsistence and industrial fishing
6. Kenya - Lake Victoria	KWS, Maxillion University	Freshwater	Fishery and lakeshore agriculture	Subsistence and industrial fishing
7. Mali - Koutiala	Struif-Bontkes & AIDEnvironment	Savannah	Cotton and livestock	Cash crop development
8. Mexico - Chiapas	CIMMyT & ECOSUR	Tropical forest	Crop and livestock	Subsidised maize and bean production
9. Nicaragua - Chontales	UCA-ADAA	Tropical forest	Extensive livestock production by smallholders	Expansion of agricultural frontier
10. Vietnam - Dakrong D.	CRES	Tropical forest	Crop and livestock	Slash and burn system at its end
11. Vietnam - Giao Thuy D.	CRES	Marine/coastal	Fishery and aquaculture	Privatisation, protection and overexploitation of the commons

- be on a geographical scale of a 'homogeneous production system', which may be a province, a landscape, a dominant production sector, or an agroecosystem type;
- focus on poor people in rural areas who depend on the local natural resource base, not on urban areas;
- focus on biodiversity-related poverty, taking socioeconomic factors into account as contextual information (demography, markets, governance, pro-poor and pro-biodiversity policies);
- be in regions where the relationship between biodiversity and poverty is an important research and development topic;
- be executed by capable, interested counterparts, consisting of a multidisciplinary team with access to quantitative data.

The research partners were selected for their area knowledge, access to data and expertise.

We selected 11 case studies (*Table 3.1*). The case studies together cover a time period from 1970 to 2005. In the Ghana case we also looked back to the period 1966–1988.

3.3 Conceptual framework

We could not find a conceptual framework in the literature that specifically focuses on the relationship between biodiversity and poverty. Some existing frameworks relate biodiversity to human well-being or explain the dependence of livelihoods on natural resources and biodiversity. Two of these frameworks were selected as starting points for this study: the Millennium Ecosystem Assessment framework (MEA, 2003) and the Sustainable Livelihoods Approach (Carney, 1998). These two frameworks were combined with our own vision and experience and the experiences and opinions of our partners from developing countries to create a new conceptual framework.

3.3.1 The MEA framework

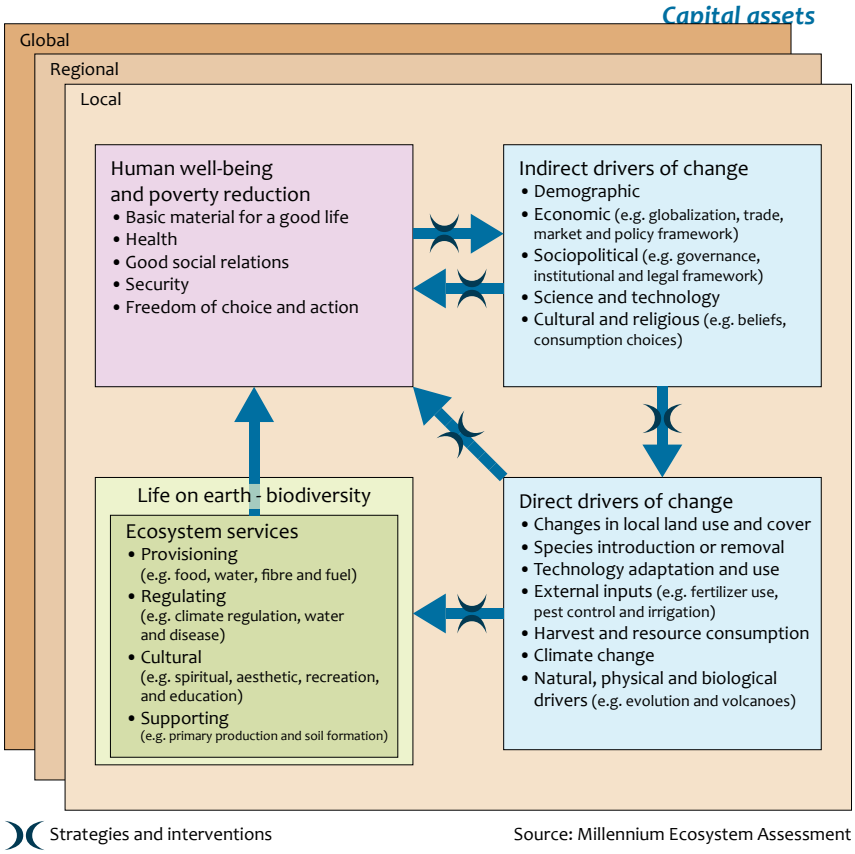
The MEA framework pays particular attention to the linkages between ecosystem services and human well-being (*Figure 3.1*). It recognises that biodiversity and ecosystems have intrinsic value and that people take decisions concerning ecosystems based on considerations of their well-being as well as intrinsic value of the ecosystem. The MEA framework addresses the multi-scale aspects of the relationship between ecosystems and human well-being, feedback loops and direct and indirect drivers of change. However, it does not take account of the different actors within a community and the distribution of wealth between the different actor groups within a community.

'Changes in factors that indirectly affect ecosystems, such as population, technology and lifestyle (upper right corner of *Figure 3.1*) can lead to changes in factors directly affecting ecosystems, such as the catch of fisheries or the application of fertilisers to increase food production (lower right corner). The resulting changes in the ecosystem (lower left corner) cause the ecosystem services to change and thereby affect human well-being. These interactions can take place at more than one scale. Similarly, the interactions can take place across different time scales. Actions can be taken either to respond to negative changes or to enhance positive changes at almost all points in this framework (black cross bars)' (MEA, 2003).

3.3.2 The SLA framework

To obtain the additional information on actor groups that is needed to identify who suffers from poverty and why, an actor differentiation was added to the MEA focus: the Sustainable Livelihoods Approach (SLA) (Carney, 1998). This approach puts people at the centre of development, which is as important at macro levels (e.g. in relation to economic reform) as it is at the micro or community level (where it may already be well embedded) because human populations that use different natural resources and enjoy different levels

Conceptual framework of Millennium Ecosystem Assessment **Figure 3.1**



The MEA framework links biodiversity to human well-being and to human and natural drivers of change (MEA, 2003).

of well-being are likely to be found at all scales. The SLA framework (*Figure 3.2*) was developed to help understand and analyse the livelihoods of the poor and is also useful in assessing the effectiveness of existing efforts to reduce poverty. The additional information on identified groups that use natural resources provided by the SLA framework is needed to enable an assessment to be made of the relationship between biodiversity and poverty.

The assumption is that people pursue a range of livelihood outcomes like health, income, reduced vulnerability, etc. by drawing on a range of assets to pursue a variety of activities. The activities they adopt and the way they reinvest in asset-building are driven in part by their own preferences and priorities. However, they are also influenced by the types of vulnerability, including shocks (e.g. drought), overall trends for example in resource stocks and seasonal variations. Options are also determined by the social structures, such as the roles of government and the private sector, and social processes, such as institutional, policy and cultural factors that provide the context within which people act. The aggregate of all these conditions determines their access to assets and livelihood opportunities, and the way in which these can be converted into outcomes. Poverty, and the opportunities to escape from it, depend on all of the factors described above.

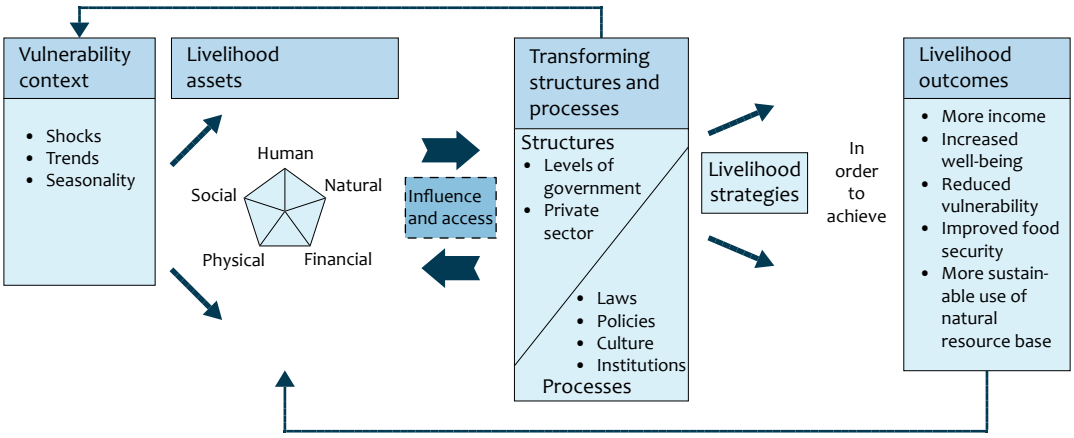
The framework identifies five types of capital asset which people can build up and/or draw upon: human, natural, financial, social and physical. These assets constitute livelihood building blocks and they can, to a limited extent, be substituted for each other. For example, the poor may draw on social capital, such as family or neighbourhood security mechanisms, during periods when financial capital is in short supply. Human well-being and poverty are therefore the result of a combination of factors, of which only one is natural capital. This means that the relationship between biodiversity and poverty can only be described within the context of the entire socioeconomic and natural system.

Capital assets

Natural capital
The nature resource stocks from which resource flows useful for livelihoods are derived, e.g. land, water, wildlife, biodiversity, environmental resources.

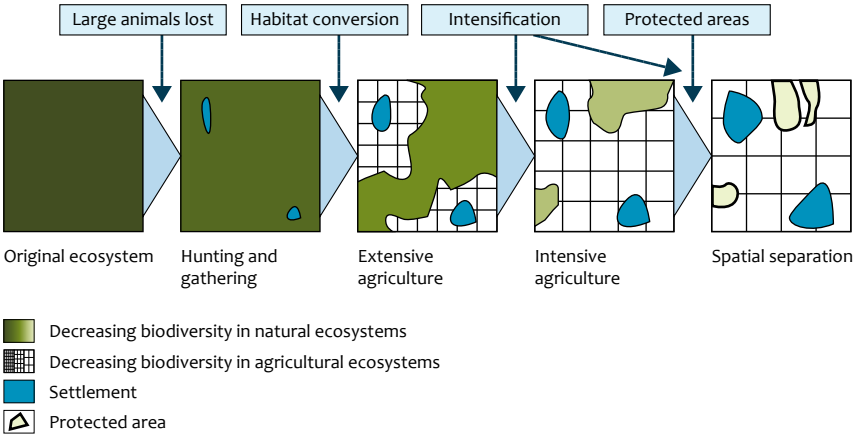
Social capital
The social resources upon which people draw in pursuit of livelihoods: networks, membership of groups, relationships of trust, access to wider institutions of society.

Sustainable livelihoods framework **Figure 3.2**



The Sustainable Livelihoods Approach (Carney, 1998).

Different stages of human intervention in natural ecosystems **Figure 3.3**



Stages of human interventions in natural ecosystems and the corresponding loss of biodiversity due to parcellation and homogenisation. In the last stage, protected areas are set aside for biodiversity conservation and form islands in parcelled landscapes of intensive production.

Human capital
The skills, knowledge, ability to work and good health are important for the ability to pursue different livelihood strategies.

Physical capital
The basic infrastructure and the production equipment and means enable people to pursue their livelihoods.

Financial capital
The financial resources which are available to people and which provide them with different livelihood options, e.g. savings, supplies of credit, regular remittances, pensions. (Scoones, 1998)

3.3.3 Human–biodiversity interactions in a long-term perspective

Developing a suitable conceptual framework for analysing the biodiversity–poverty relationship also benefits from an examination of the development of pre-historic to modern societies. This development can be seen as a long struggle to escape from poverty and become less dependent on nature (De Vries and Goudsblom, 2002; Wright, 2005; Diamond, 2004). The development from prehistoric to modern times can be broken down into three stages: from 1) hunting and gathering to 2) extensive forms of agriculture to 3) intensive agriculture (*Figure 3.3*) (Boserup, 1965; Diamond, 1999). The ecological basis of human expansion is the alteration of complex and diverse natural ecosystems with a multitude of functions into homogenous areas producing a single service at the expense of others. Such monocultures are highly productive and therefore highly profitable. Some of the lost functions are compensated for elsewhere in the form of crops, livestock, forest plantations, water retention basins, sewage treatment plants, drinking water plants, aquaculture, recreation areas and national parks. Large-scale energy crops are the latest commodity to be added to this series with the aim of safeguarding the energy supply. Human societies divide multifunctional nature into highly efficient monofunc-

tional parcels. To date, about 24% of primary production on earth has been appropriated by humans. (Haberl et al., 2007).

The domestication of wild plants and animals and the conversion of natural ecosystems into agriculture eventually raised food production by a factor 100–1000 compared with hunting and gathering (Diamond, 2004). The industrialised food production in the third stage requires major human efforts: large inputs of minerals, energy and human labour, the introduction of a small set of highly productive livestock breeds and crop varieties, and standardised water, soil and nutrient conditions. This process enabled exponential growth of the human population, from about 1 billion in 1800 to about 6 billion in 2000. This rapid population growth works against efforts to reduce poverty.

The process of increasing the efficiency and volume of food production appears to be universal, although the rate at which it proceeds differs from place to place (Diamond, 2004). At the moment, all stages of socioeconomic development can be found somewhere in the world. Modern technology and free trade permit the direct conversion of natural ecosystems into intensive production systems. The production of food, fibre and fish follow similar pathways towards highly intensive industrial production, with agriculture leading the way and fisheries and aquaculture lagging behind.

In the same way that the diversity of wild species has been reduced (homogenisation), so have the diversity of crop varieties and livestock breeds declined. The initial high numbers of varieties and breeds, reflecting adaptation to local environments, have been reduced to an ever shrinking group of highly productive races, suitable for standardised agri-environments (FAO, 2007).

3.3.4 Conceptual framework for the case studies

Based on the frameworks described above and the findings from the literature, we developed a conceptual framework for the case studies with our research partners (*Figure 3.4*). The biodiversity–poverty relationship is a multi-domain (ecological, social and economic), multi-actor and multi-scale issue. The conceptual framework used for the case studies on biodiversity and poverty was a simplified version of this complex system, focused on natural-resource-based production systems at the subnational scale. All external influences are positioned in the 'socioeconomic context' of the local system. The conceptual framework can be used to identify and understand how changes in contextual factors, access to capital inputs, or the functioning of resource-use systems may be helpful in optimising goal indicators like poverty reduction and biodiversity protection.

Socioeconomic context

The *socioeconomic context* contains factors that are largely beyond the direct influence of the *resource-use systems* and the *actors* involved at the local level (terms in italic are mentioned in the conceptual framework, *Figure 3.4*). This box corresponds to the 'transforming structures and processes' in the SLA approach, and the 'indirect divers of change' in the MEA approach. Here we find drivers at the macro level, such as trade policies, market dynamics, demographic changes, sociopolitical factors, etc. Market dynamics are determined by local and global demand and by actors such as enterprises, banks, governments and institutions. Population size and growth relates to birth and mortality rate and migration. Governance, law, law enforcement or the lack of it (corruption and violence), technology and institutional capacities indirectly determine the equality of access to and profits from resources, food availability and income per capita, and thus poverty. The SLA approach indicates that all these factors can influence the vulnerability of livelihoods. The *socioeconomic context* determines the opportunities and restrictions of the *socioeconomic system* within the case area.

Resources

The *natural system*, or ecosystem, and the *socioeconomic system* together make up the *resources* that are potentially available for the *actors in the resource use system* within the case area. Ecosystems are the fabric of life on which man depends. *Biodiversity* refers to the variety of ecosystems and life on earth at all scales, from global to genetic. Ecosystems produce *regulating, supporting, cultural and provisioning ecosystem services* (MEA) also called 'natural assets' (SLA). This report, and so the framework, focuses on provisioning services, briefly named as 'goods'. Supportive and regulating services are needed to sustain the capability to produce goods. Species populations provide stocks which man can exploit. Natural ecosystems have a closed cycle of components: substances, minerals, energy, organisms,... When man harvests from an ecosystem, the cycle becomes open, the ecosystem starts 'leaking' and loses components. Human interventions like fertilizing, soil protection, and irrigation may halt or compensate for these losses.

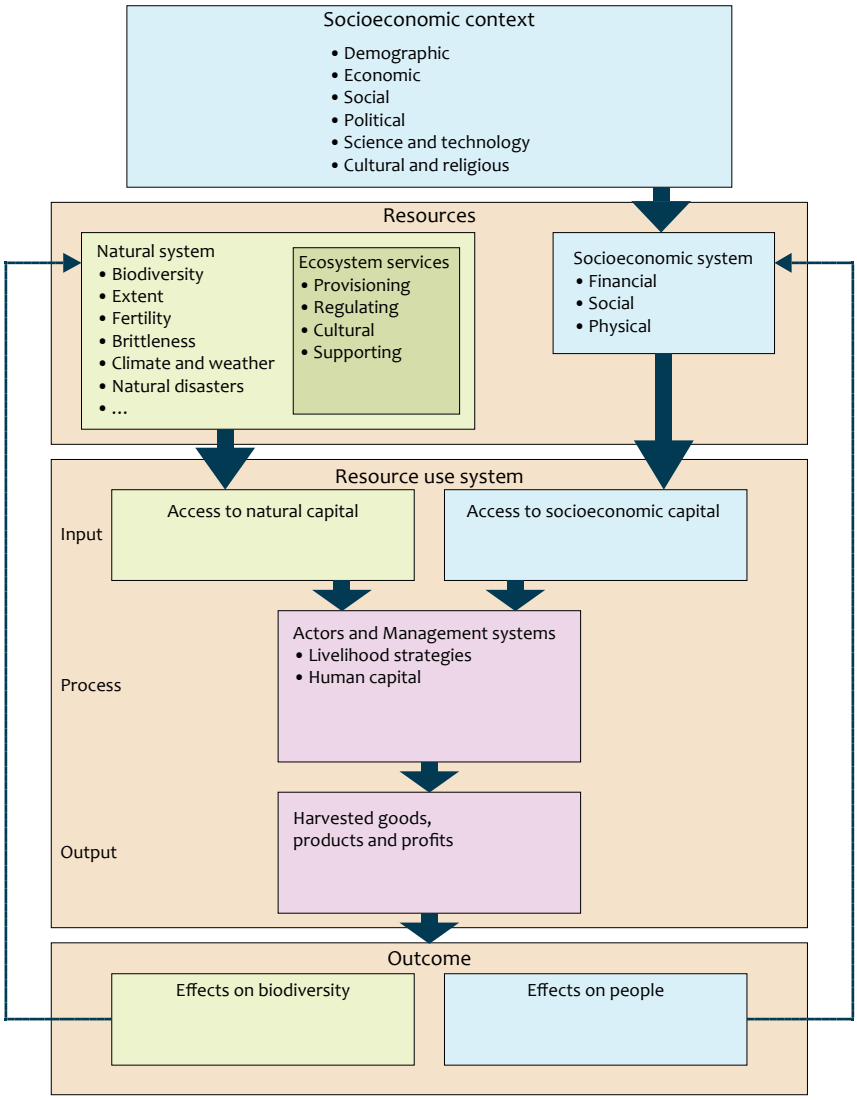
Within the biodiversity–poverty chain, the *harvested good* is the link that connects biodiversity to the socioeconomic system via products and profit, distribution of profits, income and human well-being. The ability of an ecosystem to produce goods and services is ecosystem-specific and depends on its *extent, fertility and brittleness.* Ecosystems used for harvesting can be scarce, limited or abundant. Fertility depends on climate, soil and water conditions. Brittleness refers to the sensitivity of ecosystems to human pressures and the capacity to recover from these perturbations (resilience). Non-brittle ecosystems are naturally self-regenerating systems (generally humid systems like forests), while brittle ecosystems do not recover without human management once they have passed beyond a certain level of degradation (generally semi-arid and arid ecosystems, such as most grasslands, and slopes).

The *socioeconomic system* provides *financial, social and physical assets*, as described in the Sustainable Livelihood Approach. This system is strongly influenced by the *socioeconomic context*. The level of equality, distribution systems of profits, poverty level, available capital and access to markets are important factors within this box and determine the potentials of the *resource use system.*

Resource use system

Resources are available in the case area, but not necessarily accessible to the *actor* group. *Access to natural or socioeconomic capital* is in general not equally distributed between actor types in the local community. Access to natural and socioeconomic capital varies according to the type and quality of

Conceptual framework for biodiversity-poverty linkages, used for case studies **Figure 3.4**



Conceptual framework for understanding the relationship between poverty and biodiversity in natural-resource-based production systems at subnational scale.

capital and the actor types; for example, poor actor groups often have access only to low quality capital.

The *flow of natural capital inputs* (based on ecosystems and their goods and services) and *socioeconomic capital inputs* (based on socioeconomic systems and their services) benefit the resource-use system. Both the SLA and the MEA approach do not explain how these two sources of capital interact. It is our understanding that the different states of ecosystems are characterised by a certain level of naturalness and supply of ecosystem services, while the various capital inputs will compensate for the loss of ecosystem services as naturalness declines.

The *actors andmanagement system* explain how natural and human capital inputs are processed into desirable outputs. Exploiting ecosystems requires investments to enable harvesting, such as ploughing, mowing, sawing, boats, nets, rifles, transport and labour, which require *management skills* and *access to capital*. Management systems are different for each of the *actor types*: subsistence, semi-commercial, commercial and corporate actors. Management systems are characterised, among others, by their intensity and efficiency of resource use, worldview and strategy, capacities, networks and organisation, and management decisions. In the MEA approach these are the direct drivers of change. The management skills possessed by the actors and their access to capital determine the sustainability and productivity of the harvested good. If these skills and the available capital are insufficient, the stock of natural capital will deplete and the harvest and income will decrease.

The lowest box in the resource-use system illustrated in *Figure 3.4* describes the various *outputs* that can be expected: *harvested goods, products* and *profits*. These may differ between stakeholder groups. One should think in terms of food, water, energy and shelter, but also income from the sale of goods.

Outcome

The last two boxes refer to the *effects on biodiversity and people* caused by production in the resource use system. This corresponds to the box on human well-being and poverty reduction in the MEA approach and the livelihood outcomes in the SLA approach. *Harvested goods* and related income are a condition for human well-being. Additionally, there are direct influences from the socioeconomic system on people, human well-being and poverty. Healthcare, education provisions and infrastructure for drinking water supply have direct effects on human well-being. Income distribution systems and inequality determine the amount of food or income per capita. Poverty is a function of the volume of harvested goods and related income, food security, human population size and income distribution.

Feedback loops

Feedback arrows show how the outcomes in terms of *effects on biodiversity and people* can influence the *resources* present in the case area, the *natural and socioeconomic systems*. Outcomes may directly influence these systems, such as a decline in forest or fish stocks caused by harvesting, or an increase in financial capital as a result of higher income. Outcomes may also have an indirect influence through changes in social systems that have an effect on ecosystems. For example, higher income leads to higher consumption, more infrastructure and more degradation of natural resources, but also to higher investments in the production system to compensate for losses caused by harvesting. Conversely, ecosystems may directly influence social systems; for example, degradation of the natural system will lead to emigration.

The remaining *ecosystem extent*, amount of *harvested goods* and ecosystem *management* determine the remaining *biodiversity*. In turn, *biodiversity* determines the capability to produce *goods*. There are processes that move diagonally through the framework. For instance, the *profits* obtained from *harvested goods* from the *natural system* generate income, which is invested to improve the *physical system*, such as the installation of an irrigation system. This in turn improves the *management system*, allowing more *goods* to be produced with less impact on remaining natural ecosystems and *biodiversity*.

3.4 From conceptual framework to indicators

Working with our contracted research teams, we filled the conceptual framework with candidate indicators during an iterative process of trial and error. Data for the indicators were obtained from literature studies, input from local stakeholders, workshops, expert knowledge and sharing existing datasets from different local institutes. Three questions were answered:

1. Are data available?
2. Do we need other causal factors?
3. Does the framework match the cases?

The following criteria were used in the selection of the indicators:

1. correspond with UN definitions or the CBD convention,
2. provide key information on the subject,
3. policy relevant and meaningful,
4. quantifiable, measurable, and generally available,
5. scientific sound,
6. mutually linkable,
7. sensitive,
8. enable modelling,
9. scalable, allowing worldwide comparison,
10. differentiate between resource use actor types.

The indicators were subdivided into input indicators that potentially explain the relationship between poverty and biodiversity, and the outcome indicators biodiversity, poverty, goods and services, and human well-being. The two extra output indicators - the production of goods, and human well-being - were added to reflect the indirect relationship between biodiversity and poverty.

The team leaders discussed their mid-term results in an international workshop in 2006, when the conceptual framework and causal factors were discussed and adjusted. The final reports were delivered in 2007. The 34 input indicators that were chosen are listed and defined in Annex 2. The input indicators that describe the demography, governance, policy and market factors together form the 'socioeconomic context' (*Figure 3.4*). Within the box 'resources' there are input indicators for ecosystems and socioeconomic systems. Within the resource use system box there are input indicators for actor types, access to natural and financial capital, and management systems.

3.5 Definition of outcome indicators

The outcome indicators 'biodiversity', 'goods', 'human well-being' and 'poverty' are derived from definitions in official conventions and reports that are relevant to the relationship between biodiversity and poverty in natural-resource-based production systems. The teams were asked to use the proposed definitions, but the data required for the indicators derived from these definitions could not be obtained. Other indicators were therefore chosen that matched the available data. The indicators that were finally chosen for each of the case studies are described in Annex 3.

3.5.1 Biodiversity

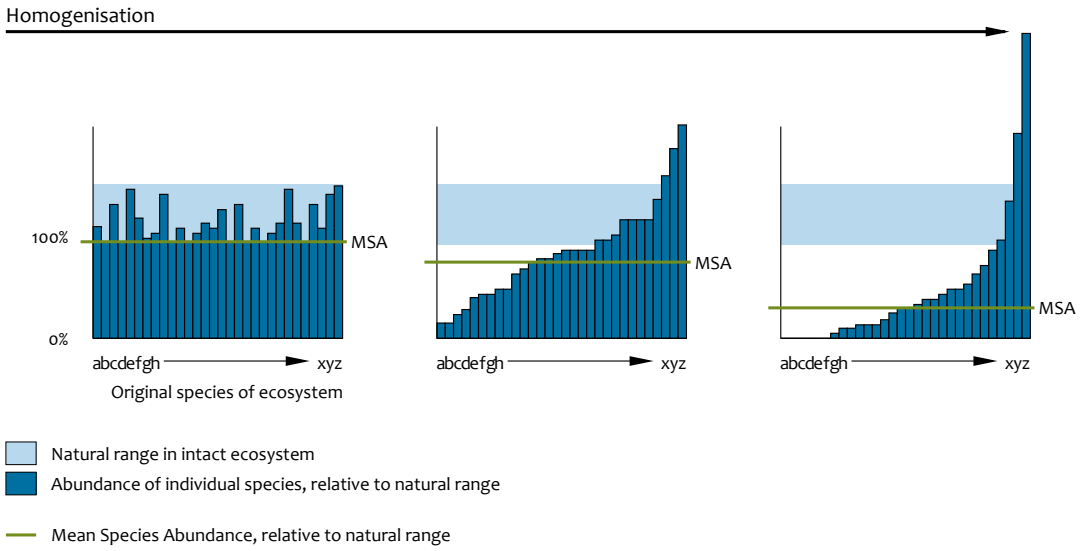
General definitions

There are many definitions of biodiversity. They deal with different organisational levels (genetic, species, ecosystems), different types of ecosystems and species (wild and domesticated), different spatial scales and one or both of the key elements 'richness' and 'abundance' (Purvis and Hector, 2000). The Convention on Biological Diversity defines biodiversity as follows: 'Biological biodiversity means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.' This definition is broad and requires elaboration.

Definition for the case studies

For this study, biodiversity is defined as the remaining original species and their abundances. It is measured as the *mean*

Process of biodiversity homogenisation expressed by the MSA indicator **Figure 3.5**



Biodiversity loss is characterised by a decrease in abundance of original species and the increase in abundance of a few, often opportunistic, species as a result of human interventions. Extinction of species (left hand side of the graph on the right, species a–f) is the last step in the homogenisation process.

species abundance of a characteristic selection of the original species (MSA) compared with the natural or low-impacted state (Ten Brink, 2000; UNEP-CBD-SBSTTA, 2003; UNEP-CBD 2004; Alkemade et al., 2009).

Mean species abundance and homogenisation

The process of homogenisation (*section 3.3.3*) is when the original species that are typical for certain ecosystems, and depend on conditions that are specific for this system, decline in number and eventually become extinct. Simultaneously a limited number of common species that are adjusted to man-made conditions flourish (*Figure 3.5*).

In practice

For most of the cases no data were available on the change of abundance of a representative set of species. The limited information that was available was on protected areas, the number of endangered and endemic species, the number of mammals, amphibians, plants and birds, species richness or ecosystem composition. Therefore, monitoring data on changes in species abundance, where available, were used in combination with the 'modelled biodiversity loss' described below. This modelled 'Mean Species Abundance' (MSA) indicator was used for all terrestrial ecosystems. For marine ecosystems the Marine Trophic Index (Alder et al., 2006; UNEP-CBD, 2004) and for freshwater ecosystems a locally designed index based on changes in fish landings were used.

As a substitute for trends in monitored species abundance and distribution, use was made of data on pressures that have an impact on biodiversity. The pressure–effect relationships were derived from the GLOBIO3 model (Alkemade et al., 2006; Alkemade et al., 2009) and the impact expressed as the change in Mean Species Abundance (MSA) over a certain period. The input used for the calculation of the change in MSA was conversion of land-use types into other types. The change in pressure on biodiversity was estimated from the change in area of different land-use types and the intensity of those land uses. Examples of land-use types in the GLOBIO3 model are agriculture, livestock farming, forestry, infrastructure and built-up area. The resulting biodiversity losses (or gains) are rough estimations, because not all pressures on biodiversity could be included in the analysis (water extraction, pollution, fires, etc.) and the model only covers terrestrial biodiversity.

3.5.2 Goods and services

General definitions

The Millennium Ecosystem Assessment includes ecosystem goods within ecosystem services: 'Ecosystem services are the benefits people obtain from ecosystems. These include *provisioning services* such as food, water, timber, and fibre; *regulating services* that affect climate, floods, disease, wastes, and water quality; *cultural services* that provide recreational, aesthetic, and spiritual benefits; and *supporting services* such as soil formation, photosynthesis, and nutrient cycling' (MEA, 2003).

Some authors differentiate ecosystem goods from services on the basis of direct profits. *Ecosystem goods* are those ecosystem properties that have direct market value. They include food, construction materials, medicines, wild types for domestic plant and animal breeding, genes for gene products in biotechnology, tourism, and recreation. *Ecosystem services* are those properties of ecosystems that either directly or indirectly benefit human endeavours, such as maintaining hydrologic cycles, regulating climate, cleansing air and water, maintaining atmospheric composition, pollination, soil genesis, and storing and cycling of nutrients. (Christensen and Franklin, 1996; Daily, 1997; Hooper et al., 2005). Costanza et al. (1997) estimated the value of the entire biosphere to be

16 to 54 * 10^{12} US dollars per year, most of which outside the market.

Definition for the case studies

As 'services' are hard to measure, we proposed that the case studies confine themselves to productivity of 'goods': change in area and productivity of the natural resource system.

In practice

Most case studies used changes in area and productivity of the cultivated land or other natural resources. The case studies in Ghana and Kenya, which were on aquatic ecosystems, used changes in catch. The Mali case also looked at soil degradation.

3.5.3 Human well-being

General definitions

There is no single measure that captures people's living conditions, quality of life or human development. The World Development Report uses criteria developed by the OECD Development Assistance Committee (DAC; World Bank, 2000/2001):

1. *Economic capabilities* mean the ability to earn an income, to consume and to have assets, which are all key to food security, material well-being and social status. They are related to access to financial and physical resources.
2. *Human capabilities* are based on health, education, nutrition, clean water and shelter. These are core elements of well-being as well as crucial means to improve livelihoods.
3. *Political capabilities* include human rights, a voice and some influence over public policies and political priorities and freedom.
4. *Sociocultural capabilities* concern the ability to participate as a valued member of a community. Important aspects are social status, dignity, geographic and social isolation.
5. *Protective capabilities* enable people to withstand economic and external shocks. Thus they are important for preventing poverty. Important aspects are vulnerability and insecurity. External shocks include natural disasters, economic crisis and violent conflicts.

These resemble the five dimensions of human well-being recognised by the MEA (2003): i) basic material for a good life, ii) freedom and choice, iii) health, iv) good social relations, and v) security.

Relevant socioeconomic indicators are Gross Domestic product (GDP) per capita, GINI coefficient for inequality in income, Worldwide Governance Indicators (WGI; World Bank, 2008; Kaufmann et al., 2006) and the Transparency International Corruption Perceptions Index 2006 (http://www.transparency.org). The Human Development Index (HDI) is a composite indicator of human development (HDR, 2002). It measures the average achievements in a country in three basic dimensions of human development:

1. a long and healthy life, measured as life expectancy at birth;
2. knowledge, measured as adult literacy rate and combined primary, secondary and tertiary gross enrolment ratio (GER);
3. a decent standard of living, measured as GDP per capita at purchasing power parity in US dollars.

Definition for the case studies

We proposed using the Human Development Index, if available.

In practice

The teams selected different indicators for human well-being, given the limited data available. As a consequence, quantitative comparison between cases became limited. Some examples of the definitions used are:

- average GDP per capita in the area;
- food production per capita in rice equivalents, which is an estimate of production at household level and income, and not necessarily food intake per capita;
- net farm income (NAI) per year, based on the average yields in the area, size and type of production system and market prices of cash crops;
- Human Development Index (HDI).

3.5.4 Poverty

General definitions

According to Sen (1999), poverty is an undesired state of human well-being, measured as a score below a certain level of human well-being. The poor generally lack a number of human well-being elements, such as income, food, education, access to land, health and longevity, justice, family and community support, credit and other productive resources, a voice in institutions, and access to opportunity. Being poor means having an income level that does not allow an individual to cover certain basic necessities, taking into account the circumstances and social requirements of the environment and society. The most basic necessity is food.

The FAO (2004) defines hunger as a condition in which people lack the basic food intake to provide them with the energy and nutrients for a fully productive, active life, and as an outcome of food insecurity. The FAO considers that chronic undernutrition is a good measure of the process of food insecurity and insufficient food production, lack of quality of the natural resources for production purposes, and the lack of access to capital for increasing productivity. Food relates to the productivity and functioning of ecosystems.

Definition for the case studies

We defined poverty as an income below the economic poverty line of 2 US dollars a day, subdivided into absolute and relative numbers (poverty rate). Income relates to the value of ecosystem goods on the market. We also chose chronic hunger – recurrent lack of access to food and constant undernourishment – to define poverty for the case studies.

In practice

The teams chose their own definitions of the economic poverty line and different proxies or substitutes. Some examples are:

- prevalence of stunting among children under five in areas of less than 2 habitants per square km (low length-for-age; FAO, 2004);
- under-five child mortality (WHO);
- poverty headcount or poverty rate according to a nationally defined poverty line;

- Human Poverty Index (HPI) if other income indicators were not available.

3.6 Analysis of results from all cases

During a follow-up study, all the cases were analysed and scores on a scale of 1 to 5 were given to each of the input indicators, the score '1' indicating an unfavourable situation and '5' a favourable situation. See Annex 1 for the scores and Annex 2 for descriptions of the scores for each of the indicators. The outcome indicators were scored from –2 to +2, indicating an unfavourable or favourable change during the investigated period.

The indicator score for all the case studies were then analysed to answer the following main questions:

- Can the indicators help better understand the cases in terms of biodiversity-poverty relationship?
- Comparing the cases, can we select a limited set from the 34 input indicators that explain most of the differences between the cases and that we can call 'determinants'? Determinants are input indicators that have a major influence on the relationship between biodiversity and poverty and on the value of the outcome indicators in a majority of the case studies.
- Can we find patterns of determinant scores that explain the poverty–biodiversity dynamics of the cases?
- Can we identify mechanisms that are driving forces behind dynamics in biodiversity and poverty and that are explained by patterns of determinant values?

We first analysed the trends in the four outcome indicators for all cases in a systematic way, and deduced causes of change and processes that could explain the combination of outcome indicator values for the cases. With these causes of change in mind, we then reduced the number of input indicators from 34 to 16, deleting 9 indicators because of lack of information or overlap, and averaging two sets of in total 11 indicators to produce to one score per set (market integration and governance). We clustered the cases into three groups based on the value patterns of the input indicators using the statistical method 'K-means clustering'. One group was further subdivided on the basis of the outcome indicators and patterns of the values of the input indicators. This resulted in four different groups of cases. From these groups we deduced mechanisms and 'prototypes' of resource use systems.

3.7 Joint learning

One of the aims of the International Biodiversity Project was:

To build a joint knowledge base on the relationship between biodiversity and poverty with our research partners.

We cooperated with three separate groups that differed for their learning goals:

1. The biodiversity team at The Netherlands Environmental Assessment Agency was interested in finding patterns of indicator values and mechanisms that determine the relationship between poverty and biodiversity.
2. The research partners and end users in the developing countries were interested in solving local problems or improving their understanding of the causes of undesired situations.
3. The policy-oriented clients of the project – environmental and development NGOs and the Dutch ministry of Foreign Affairs – were interested in improved understanding of the relationship between biodiversity and poverty to design policy theories and formulate criteria for programmes and projects.

Joint research with partners in developing countries started with the exchange of knowledge, tools and methods for analysing development processes that may affect biodiversity and poverty. The Netherlands Environmental Assessment Agency supported this effort by providing analytical frameworks, tools and knowledge, and funding to do the case studies.

When different stakeholders are involved in solving complex problems and want results at local, national or international scales, joint learning requires a step-by-step approach. Tekelenburg (2001; 2002) states that through case study research (learning in practice), and through reflection on and systematisation of several case studies (learning from practice), he was able to obtain specific insights and generic understanding about a complex problem and design new theoretic concepts and tools (learning for practice). These learning stages can also be found in this research project. The results from local learning in practice can be found in Chapter 4 which presents the case studies, and in the extended case study reports. The systematisation of case studies as learning from practice is described mainly in section 4.1 and Chapter 5. The outlook for improving conceptual frameworks and tools for application in new research (learning for practice) can be found in Chapter 6.

3.8 Significance and uncertainty

This exploratory study based on 11 case studies provided a satisfactory method for acquiring knowledge and understanding of development processes and their combined impacts on biodiversity and poverty, and for identifying the major causes of change. It was not appropriate for performing a quantitative and statistical analysis. Framing the problem, selecting case studies, compiling a conceptual framework for analysis, selecting indicators and values for the indicators, communication and definitions all involve uncertainties. Our goal of improving our understanding of the combined impacts on poverty and biodiversity was linked to research questions about sustainable development at the local scale. As such, it proved to be difficult to discuss the issues properly with our research partners. They were interested in finding options to improve production and maintain biodiversity, while we were interested in understanding historical processes.

The selection of cases, the quality of data on historical changes (drivers, pressures and impacts) and the local interpretation of the conceptual framework and definitions

had a considerable influence on the results. Comparing cases was a major problem because the time periods covered by the cases were not identical, the contexts of the cases were heterogeneous, and the geographical scales differed in area and nature, varying from a study of a production sector (one resource user), a landscape (various resource users) or an administrative unit (province). Moreover, each partner selected indicators that were available locally. We decided as a group which indicators should be calculated, but accepted proxies if data were not available.

Our exploratory study was not comprehensive. The case studies do not represent all possible development processes and all kinds of possible impacts, nor do they cover the full range of remaining biodiversity (100–0%) and poverty (100–0%).

Case studies: results

4

The results of all the cases are given in section 4.1, where explanations for the relationships found are suggested. The relationship between biodiversity and poverty within the cases can be affected by trade-off effects that exceed the geographical boundaries or the time span of the cases. These effects are described in section 4.2. Important causes of change are listed in section 4.3.

The case studies are described in more detail in section 4.4. The relationship between biodiversity and poverty was analysed in a step-by–step approach. The first step was the investigation of how change in biodiversity related to changes in the production of goods during the research period. The next step was an analysis of the change in goods to change in human well-being. The change from human well-being into poverty was the subject of the third step.

4.1 Outcome indicators for all cases

Table 4.1 Summarises the trends in the four outcome indicators for all cases. It shows how change in biodiversity coincides with change in goods production, human well-being and poverty.

Biodiversity and goods production

We assumed that extension and intensification of the production system lead to increased goods production and declining biodiversity: win (goods)–lose. This holds for 7 of the 11 cases (see last two columns of table 4.1). Explanations for deviant relationships in the other cases are given below:

- Ecosystems are vulnerable to overexploitation, depletion and erosion, leading to stagnating or decreasing productivity, combined with biodiversity loss. This seems to have happened to the Ghana fishery (1988–2003) and the Lake Victoria fishery.
- Bad ecosystem management and limitation to expansion also leads to stagnation or decline in productivity, combined with biodiversity loss, as found in the Vietnam upland.
- Biodiversity protection policies can reverse or halt biodiversity loss at the expense of production, as happened in Costa Rica with a lose (goods)–win trend and in Mexico with a neutral (goods)–neutral trend.

Goods production and human well-being

An increase in goods production is expected to improve overall economic conditions and human well-being, and vice versa. This relationship was found in 5 of the 11 cases (see the third and fourth columns of table 4.1). Apparently there are factors that hamper the passing on of profits from production to human well-being in six cases:

- In the Vietnam upland human well-being improved while production stagnated. This may be a masked effect because of the delayed response in human well-being, but also of illegal (not measured) hunting and gathering in the forests or positive impact of specific human-wellbeing programs on education and primary health care. The case

Summary of trends in outcome indicators **Table 4.1**

Case	Poverty	HWB	Goods	Biodiversity
Brazil	Win	Win	WIN	LOSE
Mali	Win	Win	WIN	LOSE
Indonesia	Neutral	Neutral	WIN	LOSE
Ghana 1966–1988	WIN	WIN	WIN	Lose
Ghana 1988–2003	Lose	Lose	Neutral	Lose
Vietnam upland	Win	Win	Neutral	Lose
Vietnam mangrove	Win	Win	Win	Lose
Ecuador	Neutral	Neutral	Win	Lose
Nicaragua	Lose	Neutral	Win	LOSE
Kenya	Lose	Lose	Lose	Neutral
Mexico	Lose	WIN	Neutral	Neutral
Costa Rica	Win	Win	Lose	Win

STRONG TREND
Medium trend

study expects a turn towards a lose–lose trend because resources will become exhausted if the production system does not change.
- In Ghana 1988–2003, Nicaragua, Indonesia and Ecuador, human well-being improved less than goods production. This could be explained by population growth and inequality, which both lead to fewer goods for all or sections of the population.
- In Indonesia, besides the above explanation, profits from goods were exported from the case area and the country.
- In Costa Rica and Mexico, human well-being improved more than goods production due to strong government intervention. In Costa Rica poor people migrated from the area.

Human well-being and poverty

In two cases, Nicaragua and Mexico, there is a difference between the direction of change in human well-being and in poverty (see the second and third columns of table 4.1). This is explained in Nicaragua by immigration of poor people from elsewhere and in Mexico possibly by unequal access to government aid.

Biodiversity and poverty

Five cases show a *win–lose* trend on poverty and biodiversity (see second and last columns of table 4.1). Mali, Vietnam upland and Ghana tended to or actually changed into a *lose–lose* trend: the system reached the limit of its production capacity per household. Soy in Brazil is the only case in which an abundance of fertile land and financial capital coincided with low population growth. Here the *win–strong lose trend* continues. In the Vietnam mangrove case, one actor group lost access to the common resources and experienced a *lose–lose trend within a wider win–lose context*. Here, an increase in productivity and private property led to increasing profits and access to international markets for the privileged.

A strong increase in productivity at the cost of high biodiversity loss in Brazil, Mali and Indonesia did not lead to strong improvements in human well-being and poverty reduction. In the Brazil and Indonesia cases, profits were taken out of the production area. In Mali and Indonesia, population growth was high and counteracted poverty reduction.

Ghana 1988–2003 and Nicaragua show a *lose–lose trend*. Two important causes are high population growth caused by immigration and overexploitation of natural resources. This coincides with high biodiversity loss in Nicaragua and a continuing overexploitation of fish stock in the Ghanaian sea.

The Hojancha case in Costa Rica is the only one that shows a *win–win* trend. This positive trend results from out-migration of poor people in combination with government payments for ecological services. The increase in biodiversity resulted from reduced exploitation. Natural capital was restored at the cost of production, as shown by the *lose–win* trend in goods and biodiversity.

Indonesia and Ecuador are *neutral–lose* cases. In Indonesia the stagnating poverty reduction combined with strong biodiversity loss was caused by a strong increase in production combined with high population growth and an outflow of financial capital. The situation is totally different in Ecuador, where emigration of poor people masks the lose–lose situation. A common factor in both cases is the brittleness of the ecosystems.

Mexico and Lake Victoria have *lose–neutral* trends. In Mexico poverty increased because a fall in export earnings were only partly compensated by government subsidies, while production levels and biodiversity remained more or less stable. In Lake Victoria the reasons are totally different. The trends result from growing population by immigration, combined with a drop in catch per unit effort due to overexploitation. Biodiversity is at a very low level.

Concluding remarks

If common natural resources are abundant and accessible, either large-scale commercial exploitation for international commodities or a rapidly growing population in search of new land to bring into cultivation – or, in aquatic systems, low investment livelihoods – may lead to strong expansion and biodiversity loss. In the analysed cases this did not lead to proportional reduction in poverty. Profits were exported from the case area (Brazil, Indonesia) or had to be shared between an increasing number of people (Nicaragua, Kenya, Ghana).

If access to natural resources becomes limited and the population keeps on growing, people intensify production (aquaculture in Vietnam, fishing in Ghana, irrigation in Mali), or natural resources become overexploited, especially when they are brittle (Ecuador, Mali, paddy rice and forest exploitation in the Vietnam upland, gathering in mudflats in the Vietnam mangrove area, fishing in Lake Victoria). If there is strong government intervention with biodiversity protection, alternative employment possibilities, subsidised jobs and emigration, negative trends can be changed (Costa Rica). If interventions are not strong enough, the negative trend continues (Mexico, fishing in Ghana and Kenya, paddy rice in Vietnam upland). If interventions do not structurally improve the production system, but only services and facilities, human well-being may improve, but poverty remains. This may even hamper progress with improving agricultural techniques and management (Mexico).

4.2 Scale and trade-off

The cases were all subnational in scale and the analyses were restricted to activities and trends within the borders of the study area and over a limited time period. The production systems of the cases are based on the use of natural resources. Some of these production systems are strongly integrated into the market and connected to global trade, others are subsistence based, but none of the cases are completely isolated from national or international influences. Goods, money, people and knowledge may cross the boundaries of the case areas, generating trade-off effects that surpass the boundaries of the case areas and the time periods investigated. These trade-off effects influence the relationship between poverty and biodiversity.

In the case studies we see the following cross-boundary effects:

- In- and outflow of goods, especially in the market-oriented cases: soy, palm oil, cotton, timber, fish, shrimps. The production of these export commodities affected biodiversity in the case areas and can be seen as the ecological footprints of the consumers living outside the area. In Ghana imported cheap fish improved the food supply. The catch of this fish probably affects biodiversity elsewhere. The method of the ecological footprint connects biodiversity loss and consumption or human well-being at the global scale.
- In- and outflow of finances, such as input from government subsidies, incomes from labourers who work outside the case area, private financial investment in an export-oriented production system or the export of private profits from the case area. The direct relationship in the case area between production of goods at the cost of biodiversity loss on the one hand and profit, improvement in human well-being and poverty reduction on the other hand is confused by these financial flows. Instead of a direct connection between biodiversity, profits and human well-being, the relationship is indirect and at a higher spatial scale, for example via the spending of tax incomes in the case area or new employment opportunities if the economy of a larger area or the whole country improves.
- In- and out-migration, especially of the poor. If the case area offers few livelihood opportunities for a growing population, people leave the area to go to the cities or abroad. Poor people from Hojancha, Costa Rica and Ecuador found new job opportunities outside the case study area. But poor people from elsewhere are also attracted by opportunities in the case areas, for example in Indonesia, Nicaragua, Ghana and Kenya. These flows can be considered to be the import and export of poverty. Here too, the scale of the relationship is broader than just the case area.
- Knowledge and technology are brought into the case area by private entrepreneurs for export-oriented production systems, and by the government or NGOs as part of development cooperation, poverty reduction and biodiversity protection policies. This may improve the resource use system and stimulate production, or offer employment opportunities with different biodiversity impacts.
- Resource depletion uses up future natural capital; protection and restoration of natural capital are investments for future production and income opportunities. Viewed this way, the relationship between poverty and biodiversity not only has a broader spatial dimension, but also a temporal and cross-generational dimension.

With these cross-boundary effects and broader spatial and temporal scales in mind, the relationships between poverty and biodiversity in the cases may differ from what we see at the local scale. For example a win–win trend changes into a win–lose trend if the ecological footprint outside the case area is taken into account, or even into a lose–lose trend if we also include the 'export of poverty'. A win–strong lose trend is a strong win–strong lose trend if profits outside the case area are included. We did not investigate these trade-off effects in the case studies.

4.3 Causes of change

The cases reveal the following important factors that explain the biodiversity and poverty trends and the relationship between these two:

1. *Population density and change*: population density and growth rate determine the pressure put on ecosystems and the size of the share from its profits (e.g. Mali, Ghana, Nicaragua, Ecuador, Mexico, Kenya).
2. *Level of poverty:* determines the capabilities of people to profit from resources, invest in improving production and skills, and affects their creditworthiness and vulnerability to setbacks (e.g. Ecuador, Ghana).
3. *Market integration, access to capital and export of benefits*: market demands and access to international markets give growth potential to local economies and may be the driving force behind biodiversity loss (e.g. Brazil, Mali, Vietnam mangrove, Indonesia, Kenya). Trade liberalisation and loss of international markets may cause stagnation of production (e.g. Mexico). Low market integration means no opportunities for economic growth as a driving force for poverty reduction (e.g. Nicaragua, Mexico). High integration into international markets coincides with access to financial and technological capital and may lead to profits from local production leaving the case area or country. If so, they do not contribute to local economies and development (e.g. Brazil, Indonesia, Kenya). Importing cheap food compensates for decreasing availability of food per person (e.g. Ghana).
4. *Actor type, skills and management capacities:* large commercial farmers have the management skills and access to technology to increase production and counter risks (e.g. Brazil, Indonesia). Subsistence farming often coincides with low management skills (e.g. Nicaragua, Vietnam upland).
5. *Productivity:* low productivity and yields lead to reclamation of more land if available, or to low human well-being (e.g. Ecuador, Nicaragua, Mexico, Vietnam upland).
6. *Alternative jobs opportunities:* jobs outside the natural resource use system may generate extra income or an outflow of poor people. If alternative jobs are not available, people stay in the production system and use the natural resources (e.g. Ecuador, Mali, Ghana, Mexico).
7. *Equality*: distribution of access to natural or financial resources and of income from the benefits of natural resources influences poverty rates (e.g. Vietnam mangrove).
8. *Governance, land ownership:* poor law enforcement, corruption and unclear landownership may lead to easy access and overexploitation of natural resources, as well as inequality (e.g. Brazil, Indonesia, Nicaragua). Government interference may improve or stabilise the situation (Ghana, Kenya, Costa Rica, Mexico).
9. *Policies:* subsidies for development, payments for environmental services, protected areas, stimulation of migration, etc. change autonomous processes (e.g. Vietnam upland, Costa Rica, Mexico).
10. *Brittle ecosystems, overexploitation, pollution and introduction or invasion of alien species:* overexploitation and degradation of natural systems lead to declining yields. Some ecosystems and some production systems are more sensitive to overexploitation than others (e.g. Ecuador, Vietnam

upland, Nicaragua). Fishery systems are 'hunting' systems, without tillage of the production system or input to compensate for the loss of matter, such as seeds, manure and water, as in agriculture. Therefore, fisheries are vulnerable to overexploitation. Catch per unit effort decreases at a higher remaining biodiversity level than is expected for terrestrial agricultural systems (Ghana). Pollution degrades the ecosystem and the introduction of alien species may totally change the ecosystem or hamper restoration of biodiversity (Lake Victoria Kenya).

11. *Access to natural resources and privatisation of commons:* exploitation of natural forest or mudflats supports people who have little or no access to financial and technological means (Vietnam upland and mangrove, the agricultural frontier in Nicaragua). Commonly owned land, forest and waters that offer living opportunities for local people are privatised by people who have the power to take possession of them, depriving local people of access to these resources (e.g. Vietnam mangrove).

4.4 Description of the cases

4.4.1 Introduction

Each case is introduced briefly, followed by a summary and illustration of the observed changes in biodiversity, production of goods, human well-being and poverty. The major causes of change are listed and the relationship between changes in poverty and biodiversity described. The description of each case study ends with a storyline that gives an overall picture of the situation.

For each case the four outcome indicators are illustrated by three graphs to assist the analysis and facilitate a better understanding of the relationship between changes in biodiversity and poverty. The outcome indicators represent a change in the situation over time and are not absolute values. They were scored semi-quantitatively on a scale from –2 to +2, ranging from a large decline or worse situation (–2) via a steady situation (0) to a large increase or better situation (+2). The scores for the change in biodiversity during the research period are plotted on the y-axis in all three graphs; the x-axes represent the scores for the change in production of goods, human well-being and poverty during the same period. The resulting three arrows show the changes in biodiversity, goods production, human well-being and poverty, the direction and length of the arrows indicating how change in biodiversity relates to changes in the three other indicators. The arrows start from the centre of the diagram, regardless of the absolute value of the indicator at the start of the research period. They show the changes in the indicators compared with the situation at the start of the research period. The described changes over time refer to the research period, unless other time periods are specifically mentioned. The source of the information for the whole case is given as a reference at the end of the brief introduction.

4.4.2 Soy Development in El Cerrado, Brazil

This case concerns the expansion of soy production in the Brazilian tropical savannah region of El Cerrado during the period 1995–2003. The international demand for soy is rising rapidly. From the early 1990s, international banks have provided growing amounts of financial capital to soy trading companies on the strength of the buoyant global soy market and attractive prices. This access to international capital and markets makes the 'technology packages' provided by soy traders economically attractive to producers, even where soy is not the most suitable crop from an ecological or food security perspective.

The rapid expansion of soy (the 'soy boom') has been achieved at the expense of the El Cerrado savannah forest. The areas where soy cultivation is expanding most rapidly are among the poorest in the country, where small-scale local farmers are especially affected. Poverty is not just a question of low income but to a large extent a low level of empowerment and organisation. Local land owners, who mainly practice extensive livestock grazing, are displaced to savannah forest, which they clear to create new range lands. (Kessler et al., 2006)

Biodiversity trend

Biodiversity was depleted at a fast rate due the conversion of natural ecosystems into agricultural land. During the research period about 11–15% of the cover of shrubs and savannah ecosystems was lost and replaced by soy cultivation and livestock grazing. Mean Species Abundance (MSA) dropped from 70% to 60%. In the Mato Grosso region over 31,000 km² of savannah was converted into cultivated land.

Production of goods

Before 1960 only a small proportion of the area was under small-scale subsistence farming. Livestock production started around the end of the 1960 and expanded rapidly and became more intensive with the introduction of highly productive exotic grasses. Soy production started in the 1980s, in some zones in the 1990s. Soy is sometimes intercropped with cotton. In El Cerrado soy covered an area of about 5 million hectares in 1995 and 10.8 million hectares in 2003, and continues to expand. Soy farmers converted natural areas or bought land from ranchers. In turn, the ranchers forced small farmers to move into the savannah forest. The production of livestock and soy increased quickly, whereas the production of local food, fibres and energy decreased. The first signs of soil erosion and nutrient depletion were observed.

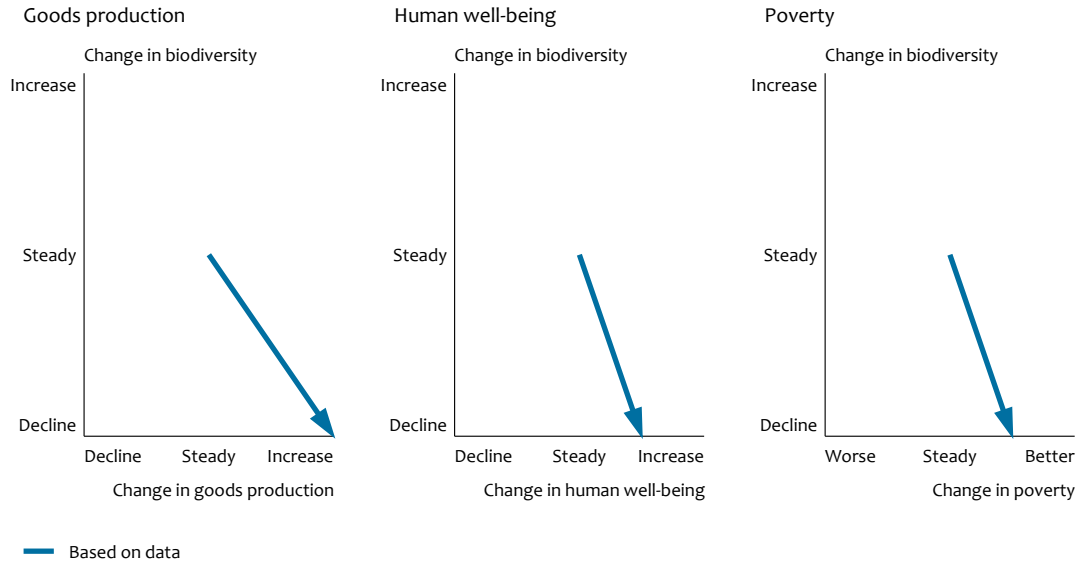
Human well-being

In 1995 the HDI and GDP per capita was on average similar to the national average. Both indicators increased at faster than the national rate. Other socioeconomic indicators, such as employment, food security and equality, worsened in absolute terms. Small farmers and indigenous peoples (hunters and gatherers) were frequently victims of land conflicts and removed from their land by force.

Poverty

Poverty levels were lower than the national average in the established zones where soy cultivation started earlier (Central), and higher in the frontier zones (New North), where soy expansion started later. Extreme poverty (below 25% of the minimum salary in 2000) and poverty (below 50% of minimum salary in 2000) were less prevalent in the established soy regions. By 2000 poverty in the frontier regions

Biodiversity and socioeconomic indicators: Soy in El Cerrado, Brazil 1995 - 2003 **Figure 4.1**



Decline in biodiversity coincided with growth in the production of goods and human well-being and a decline in poverty in the El Cerrado region of Brazil during the period 1995–2003.

was twice the national average, but the situation had been improving since 1991.

Major causes of change are:

1. increasing global market demand for soy;
2. access to cheap capital and highly mechanised and productive systems;
3. high access to vast amounts of cheap land suitable for the commodity;
4. economic stimulus policies: road building, lack of trade barriers and tariffs, low taxes;
5. poor law enforcement (land ownership).

Relationship between poverty and biodiversity

The study revealed a strong decline in biodiversity, which was linked with a strong increase in goods produced, a modest increase in human well-being and a modest decline in poverty (*Figure 4.1*). A number of poor people did not benefit. The decline in poverty and increase in human well-being were modest due to the transfer of profits from the case area and growing inequality.

Storyline for a win–lose trend:

Large-scale, export-oriented commodity development in thinly populated areas

Soy development in El Cerrado is a typical case of a highly market-oriented economy with high potentials for poverty reduction because of increasing production. A sustainable growth pattern is expected because contextual factors are favourable or regular. Soy production is expanding because the international demand is high. Access to land is high because of the low population density and access to capital inputs is high because of market demand. It is a large–scale and highly productive mechanised resource-use system, run by well-trained corporate farmers who have good skills and management capacities. Policies are relatively balanced, governance is regular, and ecosystems and social systems are not exceptionally vulnerable. However, there is a group of small farmers who sell their land to the soy producers or livestock farmers and start production elsewhere in the forest under bad conditions and low well-being, causing deforestation and a moving agricultural frontier. Claims on biodiversity are high, while existing pro-biodiversity policies are not strong enough or are not being enforced. The prospects for a more positive development are moderate, provided that the high global demand for soy can be properly managed. Recent developments show that positive progress is being made with increasing production at lower cost to biodiversity by integrating livestock with soy production. It is an example of a 'win more-lose less' trend.

4.4.3 Reforestation in Hojancha, Costa Rica

Hojancha is one of few areas in the world where forest cover has increased over recent decades, due to forest regrowth and the establishment of forestry plantations. Special attention has been given to teak farm development. The Hojancha canton is situated in the northwest of Costa Rica. The land was originally covered by semi-deciduous tropical forest. From about 1910 the area was colonised by subsistence farmers and coffee, grain and livestock farming gradually became the main production activities. As a result, forest cover decreased to below 20%. At the end of the 1960s the population reached its peak of 30 inhabitants per square kilometre. The collapse of the international meat market in the 1970s resulted in a large outward migration and the population decreased by more than half in a few years, but grew again slightly after the 1990s. Due to the sudden emigration, pastures were abandoned and this resulted in forest regrowth. The forest recovery was speeded up by several forestry incentives from the government introduced in 1969 and large foreign investments, and teak plantations were established in Hojancha. In 1991 the government introduced

Biodiversity and socioeconomic indicators: Reforestation in Hojancha, Costa Rica 1970 - 2000 **Figure 4.2**

Because of reforestation, goods production declined and biodiversity and human well-being increased in Hojancha, Costa Rica during the period from 1970–2000; poverty probably declined.

payments for environmental services. By 2005 forest covered 55% of the land surface. The case describes the period from 1970 to 2000 (Vallejo et al., 2006)

Biodiversity

Biodiversity recovered in Hojancha. The area of primary forest decreased from about 18% to 12%, but was compensated by expanding forest cover. The calculated MSA for the case area increased from 22% in 1970 to 56% in 2005. The calculated MSA growth in this period is probably too optimistic because in reality regrowth takes longer.

Production of goods

The dominant pastoral land use changed from 60% in 1970 to 20% in 2000 and cropland decreased from 22 to 10%. In the focus area secondary forests increased from nil to over 40% and forest plantations from nil to 20%. Agricultural and livestock productivity decreased over time. Forest activities accounted for 30% of total income in 2002. Tourism became an important economic activity in the region. Incomes from forestry incentives and payments for environmental services were substantial. The share of timber production (harvest) from plantations increased from 5% in 1995 to 45% in 2002. In the case area, the economic contribution to GDP from agriculture, livestock and forestry combined (natural resource use) probably declined.

Human well-being

The Human Development Index in Costa Rica increased from 0.55 in the 1960s to 0.84 in 2003. The HDI in Hojancha was probably slightly lower than the national average for Costa Rica. The GDP per capita in Costa Rica grew from US$702 in 1940 to US$3315 in 2000. GDP per capita in Hojancha probably was significantly lower, but followed the same growth rate.

Poverty

By the year 2000, 23% of the families in Hojancha had an income of less than US$66 per month, 56% had an income above US$66 and less than US$132 per month and 21% had more than US$132 per month. Hojancha experienced a large seasonal out-migration during the dry period of the year as people sought additional income. Although no relevant data are available, poverty probably declined during the study period (*Figure 4.2*).

Major causes of change are:

1. land use change as areas used for agricultural livestock production were abandoned (Hojancha experienced a socioeconomic disaster when in the 1970s the international meat market collapsed);
2. out-migration by jobless day labourers, landless and poor farmers who depended on livestock production;
3. vulnerability of people to poverty, which was and still is medium to high, despite government support (pro-poor and pro-biodiversity policies).

Relationship between poverty and biodiversity

Abandonment of agriculture and decreasing economic value from natural resource use coincided with a net biodiversity gain, while human well-being was improving: a win–win trend. But the situation was masked by government interference and trade-off effects. If the international meat market had not collapsed, the national economy had not offered alternative jobs opportunities to poor people outside natural resource use, and the government had not subsidised forestry, reforestation and payments for environmental services, the trend line would likely have been win–lose or lose–lose. The out-migration of poor people pushed poverty down, as did the income support from the government.

Storyline for a win–win trend:

Policy supported biodiversity recovery after the collapse of the international market

The meat market collapse caused a large out-migration of poor people, especially jobless day labourers, other landless and poor small farmers. The urban centres provide better job and income opportunities. This redistribution of poverty is a crucial factor that explains the increase in human well-being in Hojancha without an increase in pressure on natural resources. In addition, several policies and institutional frameworks established to promote agricultural diversification and increase forest activities led to improvements in the incomes of landowners. All land is in private hands and land for new farms is not available. The implementation of the second and third forest laws, in combination with an increasing national demand for wood products, led to an increase in the area of forest plantations. Payment by the government for environmental services is considered to be a very successful instrument for biodiversity conservation. Human well-being in Hojancha is still lower than the national average. Poverty persists outside the agriculture/forestry sector among the urban poor and landless. Unemployment rates show that the area is still vulnerable to poverty.

4.4.4 Peasant mixed farming in the Cotopaxi Highlands, Ecuador

The agricultural production sector in the province of Cotopaxi in the Andes can be subdivided into the large-scale, export-oriented sector in the main valleys and tropical lowlands, and the smallholder *campesino* production system, based on extensive, subsistence mixed production. The case study focused on the smallholder *campesino* production sector in the highlands of Cotopaxi, without making any further distinction between farming types or levels of poverty.

Biodiversity loss is directly related to land use and to the in/out-migration dynamics of people in the province. Demographic trends produced by population growth and internal migration flows resulted in a concentration of people in certain areas (development poles in the valleys and cities) and a shifting agricultural frontier. *Campesino* farmers suffer bad social economic conditions, especially along the agricultural frontier. Accessibility (in journey time) of the natural resource base for exploitation plays an important role in explaining where land use change, biodiversity loss and poverty can be found. This process of land use change caused the loss of natural ecosystems of global importance, such as paramo bush land, mist forest and evergreen forest.

Land use and environmental data from remote sensing as well as socioeconomic and population data (census at lowest administrative units) were gathered for 1982, 1990 and 2001. (Sáenz Malki, 2006)

Biodiversity

In the 1990s, the natural area declined by about 500 km² and in 2001 just 28% of the case area was natural. The agricultural area increased by 669 km² (+18%), while pasture area decreased by more than 150 km². Farming activities shifted towards the tropical lowlands and protected areas on the mountain slopes. The loss of biodiversity was almost 1% of the natural area per year, amounting to a total loss of MSA of 24% between 1970 and 2000.

Production of goods

The Cotopaxi region is characterised by a high predominance of fragile ecosystems, which are susceptible to irreversible degradation because of the altitude, cold winters, the long dry period and steep slopes. More than 75% of the area was fully exploited in 2001, or 4570 km² of a total of 6015 km². The number of farmers and farms increased, but in 2001 little suitable land remained for conversion into agricultural use. Most farmers are highland peasants and practice mixed farming on less than 5 hectares. The biodiversity claim (loss) per household is therefore low. No data were available on the goods produced by these farmers, but cropland and pasture land increased by 20–30% from 1990 to 2001. Because there is no evidence that the productivity of the land decreased, it can be assumed that the production increased in proportion to the increase in cultivated area.

Human well-being

Population growth in Cotopaxi was 0.9 % per year, lower than the national average of 2.0 % per year. No data were available on income per capita and access to education or health care. There was no evidence that it had changed significantly.

Poverty

From 1990 to 2003 the Human Poverty Index decreased slowly from 0.80 to 0.73 in the case area, and from 0.58 to 0.56 nationally. Cotopaxi remains one of the poorest provinces in Ecuador. In absolute terms the number of poor people remained more or less unchanged. Child malnutrition decreased from 60% to 45% in the case area, and nationally from 44% to 29%. Among children under five years old in Cotopaxi, 33% suffered from chronic malnutrition in 2003. Improvement in the situation in Cotopaxi lags 10 years behind the national average.

Major causes of change are:

1. population growth and colonisation of new land in the agricultural frontier zone, as well as emigration to urban centres;
2. the *campesino* community is vulnerable to poverty and has low credit worthiness;
3. no alternative job opportunities in the case area;
4. low labour and land productivity;
5. degradation of the natural resource base;
6. unequal access to high-quality land.

Relationship between poverty and biodiversity

Biodiversity declined while the number of poor people stayed the same: a neutral–lose trend (*Figure 4.3*). Population growth is the main reason for poverty levels remaining the same while production increased. Without emigration, poverty and biodiversity loss would have been worse, but if poor people had not migrated out of the case area, the trend would probably have changed into lose–lose. The signs of an imminent lose–lose trend are:

- first signs of land degradation and erosion;
- ongoing conversion of marginal land;
- labour productivity cannot be improved;
- no further market integration takes place;

Biodiversity and socioeconomic indicators: Peasant mix-farming in Cotopaxi Highlands, Ecuador 1990 - 2001 **Figure 4.3**

Goods production increased while biodiversity decreased, but human well-being and poverty did not improve among peasant mixed farmers in the Andes Highlands during the period 1990–2001.

- lack of skills for better land management and alternative jobs.

Storyline for a neutral–lose trend with tendency to lose–lose: *The end of the moving agricultural frontier and emigration of poor people in Cotopaxi, Ecuador*

Ecuador is a typical case of a subsistence-oriented economy with little potential for poverty reduction and mostly unfavourable contextual factors. *Campesino* farmers practice their subsistence-based mixed farming in densely populated areas. Historically, this situation has resulted in a continually moving agricultural frontier as new land is occupied by young families. The farmers live in poverty and have difficulty accessing the market. Labour productivity is low as the small plots of land are cultivated using low grade farming technologies, which means that agricultural productivity is also low. Access to new land is currently becoming difficult and migrants are forced to cultivate land that is less suitable for production. In these remote areas they also suffer from poor market integration and a lack of primary healthcare and education services. Faced with this situation, a steady flow of poor people emigrate to the tropical lowlands, the urban centres in Cotopaxi province and also to the national capital (a poverty pump). Areas that were colonised two generations ago are now exporters of poor people. The remnants of the original biodiversity and protected areas are under pressure, without a structural solution for increasing human well-being and alleviating poverty.

4.4.5 Oil palm development in Indonesia

Since 1990 the cultivation of palm oil has expanded faster than any other crop. World palm oil consumption more than tripled from 11.3 million (metric) tonnes in 1990 to 34.9 million tonnes in 2005. The biggest increase in production of palm oil has been in Indonesia and Malaysia and each country now produces 43% of the world's palm oil. This case study focuses on large-scale production of palm oil, which accounts for the majority of Indonesian production. By far the largest share of Indonesia's palm oil production is on Sumatra (83%), followed by Kalimantan. The provinces investigated in the case study make a higher than average contribution to Indonesia's total palm oil production. They were selected because the timber industry is less active in these areas, making it easier to isolate the effect of palm oil production on deforestation, land use and socioeconomic development. The data applicable to these provinces cover the period from the mid 1990s to 2002. (Kessler et al., 2007)

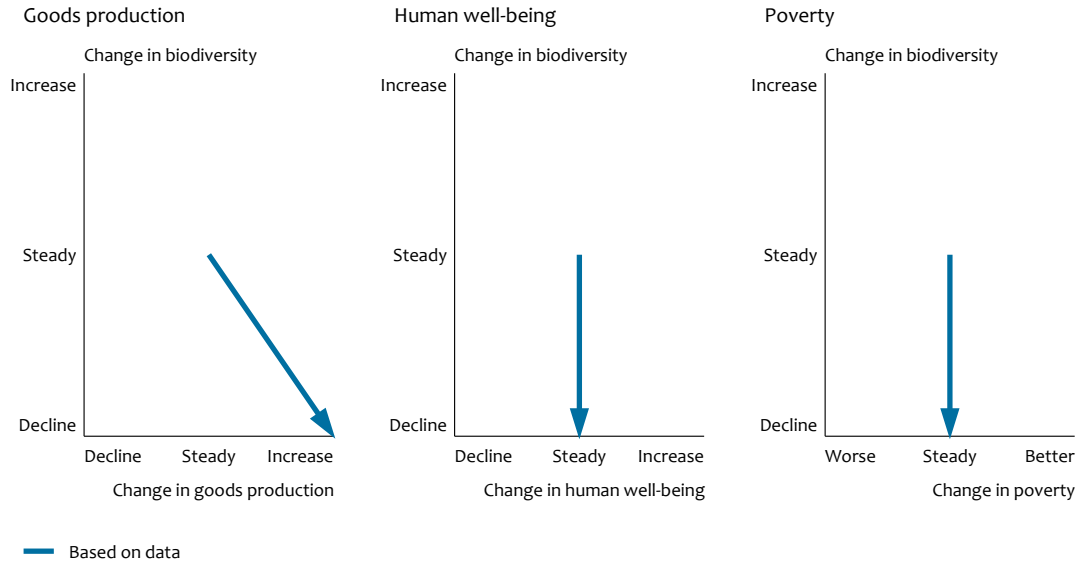
Biodiversity

Biodiversity is under pressure from deforestation. The average forest cover (41%) in the oil palm growing provinces was below the national average of 50% in 1997 and has subsequently decreased at a rate of 2% per year. During the study period millions of hectares of forest were destroyed by forest fires, 80% of which were deliberately started to clear forest for agricultural production. About three times the land surface of the Netherlands, 12 million hectares, was cleared for oil palm plantations, without being subsequently planted with oil palms. These areas were left fallow or were used for other purposes. According to the Palm Oil Research Institute, in the whole of Indonesia, 66% of oil palm plantations were established in forested areas, of which only 3% was primary forest. WWF estimated that 18% of Indonesia's primary forest was lost by oil palm plantation.

Production of goods

The area under oil palm cultivation increased explosively in 1980 and a second boom began in 1995. Palm oil production increased from 4 million tonnes in 1995 to 16 million tonnes in

Biodiversity and socioeconomic indicators: Palm oil development, Indonesia 1996 - 2002 **Figure 4.4**



In the palm oil producing provinces in Sumatra and Kalimantan, Indonesia, biodiversity decreased strongly while production of goods increased and human well-being and poverty stayed the same during the period 1996–2002.

2006. In early 2008, Indonesia reported 7.3 million of hectares under oil palm.

Human well-being

The HDI decreased on average by 2% at the national level, and at the same rate in five major oil palm production zones. In 2002, the GINI coefficient in the oil palm provinces was slightly better than the national average.

Poverty

In 1996 the Human Poverty Index in the palm oil provinces was 0.27, higher than the national average (0.22). The HPI improved slightly by 0.002 on average over the research period ('stable'), but differences between oil palm zones were high. Child malnutrition decreased.

Major causes of change are:

1. increasing international demand for palm oil: between 1995 and 2005, Indonesian export volumes increased by 443% and the value of exports increased from US$1.5 billion in 1995 to nearly US$6 billion in 2005;
2. the powerful position and organisational strength of the oil palm sector: 27 large palm oil business groups dominate the sector and 13 groups are foreign (mostly Malaysian) owned;
3. policies that actively promote large-scale plantations: an average plantation is between 6000 and 12,000 hectares in size, although plantations of 20,000 hectares are not uncommon, and single corporate groups commonly operate 200,000–300,000 hectares throughout the country;
4. access to large areas of almost unoccupied and communally owned forest: it became easier in recent decades for private companies to acquire access to land as Indonesian legislation increasingly favours investment rights over community rights;
5. resettlement programmes for poor people from elsewhere: over the years, more than half a million smallholders have been included in different smallholder schemes, which generally consist of out-grower models in which smallholders are attached to state-owned or privately-owned plantations;
6. weak governance: on Transparency International's Corruption Perception Index for 2006, Indonesia scores 2.3 out of 10, placing it among the most corrupt countries of the world, while corruption is also prominent in the palm oil sector.

Relationship between poverty and biodiversity

Increased production of palm oil through expansion and land conversion caused biodiversity loss, while poverty was on average stable in the production zones: a neutral–lose trend (*Figure 4.4*). People did not benefit because of the transfer of profits from the case area, growing inequality, corruption and immigration of poor small farmers.

Storyline of a neutral –lose trend:

Large-scale, export-oriented commodity development with poor governance and unequal distribution of profits

Indonesia is a typical case of a highly market-oriented economy (palm oil) with a high potential for poverty reduction. However, socioeconomic impact in the production areas is not as high as expected. An unsustainable growth pattern can be observed due to unfavourable contextual factors. Compared with the soy case study, population densities are higher in the oil palm regions, a situation which is bolstered by the resettlement programmes in Indonesia. Important factors are poor governance, unfavourable policies for biodiversity and the high vulnerability of ecosystems, while markets are very favourable for expansion of palm oil production and access to both natural and financial inputs is very high. Social vulnerability and efficiency of manage-

ment systems are moderate. Severe biodiversity impacts are associated with the rapid expansion of palm oil production, with high impacts on biodiversity and ecosystem services. The dominant actor type is large-scale corporations, with or without an out-grower system of resettled small farmers. Profit from production does not remain in the region and is not equally distributed among the population. As a result, the impacts on biodiversity are severe and on human well-being and poverty are moderate.

4.4.6 Cotton development in Koutiala, Mali

The Koutiala region is located in the south-eastern part of Mali, one of the poorest countries in the world. Traditionally, the population of Koutiala were mainly subsistence arable farmers, growing crops such as sorghum and millet. Since World War II rain-fed cotton has been introduced as a cash crop, along with animal traction. This has commercialised farming, although food crop production for own consumption continues to play an important role. Income from cotton production is invested in cattle, first for use as draught animals and subsequently also as a form of savings account in which the animals are considered the capital and the calves the interest. This case covers the period from 1980 to 2005.

As agriculture became a profitable business, out-migration remained at a low level and the number of farms continued to increase. This led to an expansion of cultivated area from 25% to 75% of the suitable land, reducing the area of sylvo-pastoral lands. The combination of an expanding cropping area and an increasing herd size leads to overexploitation of the resources, conflicts over access to grazing areas, soil degradation and loss of biodiversity. Four farm types are distinguished: the biggest farms grow more cash crops and have more than 10 head of cattle. The smallest farms only grow food crops and rarely possess cattle. (Struif Bontkes et al., 2005)

Biodiversity

During the study period the pressure on biodiversity from land use change was high and the proportion of land in agricultural use increased from 25% to 75%. The remaining sylvo-pastoral area was over-exploited as herd sizes increased. The average tree cover decreased from 24% to 19%. Harvesting of edible plants and hunting constituted 30–50% of the pressure on forest.

Production of goods and services

The number of farms increased from 28,928 in 1983 to 39,522 in 1996 and the area of cropland increased from 2.7 million to 3.8 million hectares. The number of cattle increased from 50,000 in 1980 to 300,000 in 1993 and has continued to increase. The average annual wood cut was estimated at 0.8 m^3 per person per year. From 1980 to 1993 the feed production in sylvo-pastoral areas decreased from a 100% surplus to a deficit of 50%. From 1990 to 1998 cotton yields dropped from 1.3 to 1.0 tonnes per hectare owing to soil degradation and pesticide resistance. During the same period the percentage of organic matter content in topsoil fell from 0.85% to 0.7%.

Human well-being

Prices of cotton and maize were good in most years and incomes doubled for all farm types, which differ in size, crop choice and livestock. The number of larger farms with the highest incomes increased between 1980 and 2005. The trends in farm types indicate that human well-being increased rapidly.

Poverty

The rural population increased from 280,000 in 1980 to 550,000 in 2005. The trends in farm types indicate that poverty levels among natural resource users were significantly reduced and the total number of poor farms fell by half. People in the Koutiala region did not suffer from hunger.

Major causes of change are:

1. population growth;
2. high incomes from cotton;
3. lack of job alternatives outside the region;
4. cotton promotion policies: guaranteed price, seed supply, credit supply system;
5. soil fertility decline and increasing pest resistance;
6. increasing herd sizes as a form of savings account;
7. lack of alternative energy sources, other than fuel wood.

Relationship between poverty and biodiversity

Increased crop and livestock production caused biodiversity loss and led to a significant reduction in poverty: a win–lose trend (*Figure 4.5*). High population growth and the first signs of overexploitation of pasture land, decreasing cropland fertility and decreasing cotton productivity are a threat. Cotton price regulations, government subsidies and agricultural expansion counterbalance effects from resource degradation and mask an underlying collapse towards a lose–lose trend.

Storyline for a win–lose trend, with first signs of lose–lose

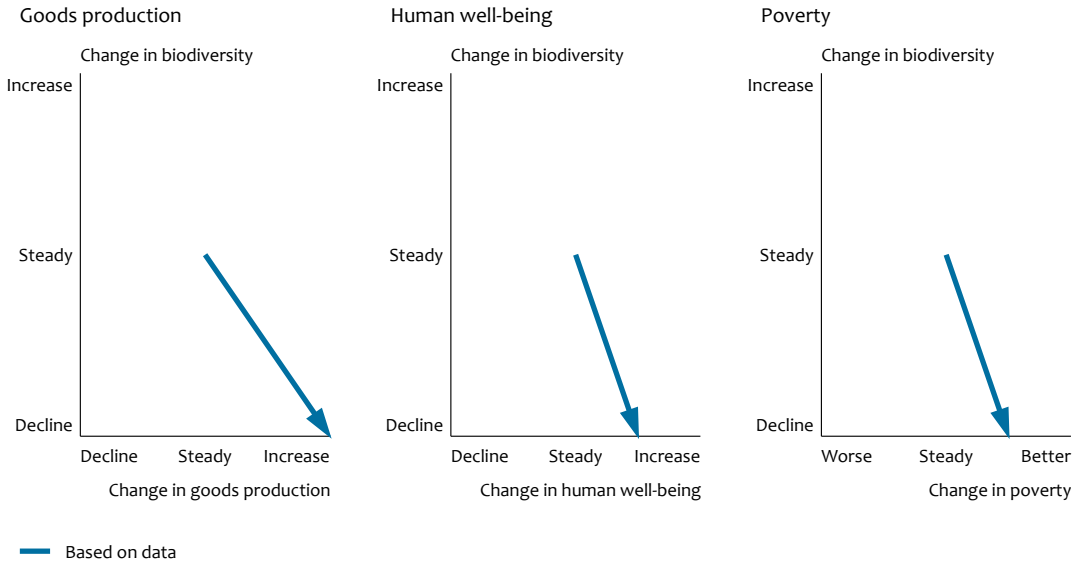
Integration of local farmers into the international market

Mali represents a market-oriented economy (cotton) based on small-scale, organised farming, with a reasonable potential for poverty reduction. Most of the important contextual factors are favourable to moderate. The cotton sector in Mali is heavily subsidised and managed by a semi-governmental parastatal organisation. This 'pro-poor' policy supports the better-off farmers, but does not reach the poor, subsistence-based peasants. Nevertheless, a number of poor farmers have started to grow cotton. If suitable land is still available for expansion of cotton growing, the proportion of households with an income below the poverty line can be reduced. As a result, impacts on biodiversity are high and impacts on the well-being of the cotton growers are good, but there is no improvement in the well-being of the subsistence farmers. Prospects for the future are negative because the amount of land suitable for cotton production is declining and grassland is becoming overstocked. Biodiversity impacts are associated with the expansion of cotton growing and livestock farming dominated by the semi-commercial actor type.

4.4.7 Maize and bean system in Chiapas, Mexico

The study area is situated in the important agricultural region of La Frailesca in the state of Chiapas in southern Mexico. The two Nature Protection Areas (NPA) located in this region are affected by conversion of natural habitat to other land uses. Fragile ecosystems predominate in the mountains zones, which are susceptible to irreversible degradation. Forest areas have been cleared for conversion into arable and grazing land. When agricultural activities decreased some decades

Biodiversity and socioeconomic indicators: Cotton development in Koutiala, Mali 1980 - 2005 **Figure 4.5**



Biodiversity decreased while production of goods and human well-being increased and poverty decreased in Koutiala, Mali during the period 1980–2005.

ago, invasive pioneer species began to occupy important ecological niches and as a consequence the original biodiversity has not been restored. The case study focused on eight rural communities in the municipality of Villaflores, which includes two types of ecosystems: the highlands and the valleys.

The maize-bean production system is the single most important threat to biodiversity conservation and the greatest driver of habitat destruction and change in Mexico as in the whole of Central America. In 2001 it covered 65 million hectares and involved 11 million people and 1.4 million producers. Central America and southern Mexico are primarily agricultural societies and depend on agriculture as a livelihood strategy. Just over half the population live in rural areas and agricultural activities account for 32% to 75% of employment. In the case area rural families depend on government support for a large proportion of their income. Following the signing of North American Free Trade Agreement in 1994, policies have been put in place to improve human well-being, increase family income and strengthen national production. The case describes the period between 1980 and 2005. (Hellin et al., 2006)

Biodiversity

Biodiversity decreased between 1980 and 2005 in the mountains. Biodiversity loss in the buffer zones of the protected areas was locally 15% MSA. Biodiversity loss in the valleys was 1.5% MSA, where secondary forest regrowth on abandoned agricultural land was observed. However, rather than broad-leaved species, pioneer *Pinus* species are colonising this abandoned land. In total, biodiversity did not change much in the case area.

Production of goods and services

Fragile mountain ecosystems predominate and these are susceptible to irreversible degradation. Extreme weather events frequent the area and people suffer from the damage they cause. Severe erosion and decreasing crop productivity as well as low market prices led farmers to abandon farmland on the slopes and regrowth forests were exploited as a source of non-timber forest products. There was little illegal land conversion. On average, total production from land use was stable.

Human well-being

The government supported the improvement of housing conditions, drinking water services and electrification in locations where poverty was highest and social services were lowest. Indices of human well-being showed important improvements.

Poverty

In 2005 the Human Poverty Index was 0.17, which was high compared to the national average of 0.07. Between 1980 and 2005 the number of poor people in the area increased, especially those that had no access to government support. At least 20%, but often up to 30% of the income of rural families in the case study was in the form of governmental support, consisting of monthly payments to the farmers according to the area of land that they have under cultivation, and a medical support and education programme for women with children. Farm innovation did not take place. Money sent home by temporary and permanent emigrants was also an important source of income. In the 1980s the government gave support to poor people from elsewhere to colonise the area. Only a few decades later the area became a net exporter of poor people.

Major causes of change are:

1. population growth and migration: the total population in Chiapas increased from 2 million in 1980 to 4 million in 2000; the population in urban areas grew considera-

Biodiversity and socioeconomic indicators: Maize and beans in Chiapas, Mexico 1980 - 2005 **Figure 4.6**

Biodiversity and the production of goods stayed about the same, human well-being improved substantially, but poverty increased within the maize and bean system in Chiapas, Mexico during the period 1980–2005.

bly as young men in particular left the area to find work elsewhere;
2. low market potentials;
3. pro-poor policies: the government provided basic services such as electricity, drinking water supply and drainage to communities in remote areas, income support for cultivated land and medical and educational support to women with children;
4. production of maize and beans at subsistence level is not economically nor ecologically feasible: access of Mexican products to the international markets dropped following the North American Free Trade Agreement (NAFTA) and Mexican production systems (small farm size and subsistence-based) cannot compete at the international level;
5. brittle ecosystems: the forest coverage in Chiapas decreased by 21% between 1975 and 1999, which caused increasing erosion, and high erosion risk zones expanded by 26% in the same period;
6. suboptimal production investments: farmers invested in the size of the crop area instead of improving farming techniques and technologies, which may lead to accelerated soil degradation;
7. no access to new land: the ban on deforestation and the biodiversity protection areas prevent farmers from increasing their farm sizes or establishing new farms, although deforestation occurs in remote areas where land clearance cannot be controlled.

Relationship between poverty and biodiversity

Production and biodiversity were more or less stable, human well-being increased, but poverty also increased: a neutral–lose trend, although degradation of the natural resource base has not yet become serious (*Figure 4.6*). Access to natural resources was limited by a ban on deforestation and the introduction of the protected area system for biodiversity conservation. Government support masked the problems of poverty. There was an ongoing out-migration of poor people seeking employment elsewhere as cheap labour.

Storyline for a lose–neutral trend with strong governmental interference:

Maintaining the status quo with subsidies, human well-being support and biodiversity conservation after entering international free trade

Mexican governance is oriented towards international trade agreements and social-environmental conventions. The North American Free Trade Agreement package seeks to increase market relations with the USA and improve national income, but this policy does not really support the rural population. The Mexican government offers small farmers subsidies to compensate for income lost to 'market distortions', without providing them with the skills to improve productivity and access to the market. The low productivity and non-competitive production structures remain in place and farmers depend on subsidies for their living. Pro-human well-being policies were also adopted and the government supports the improvement of housing conditions, drinking water services and electrification in locations where poverty is highest and social services are weakest. Indices of human well-being show important improvements, but these results cannot be attributed to the production system. People remain vulnerable to economic poverty because the productivity and profitability of the main crops have not improved. Expanding the production area is not an option because of the ban on deforestation and biodiversity protection policies. An important poverty reduction strategy for rural families is migrating to other areas or to the cities to earn money for investments in improving production and to purchase livestock. The case study area has become a source of out-migrating poor people. The social conditions of the population from the focus area impro-

ved between 1980 and 2005. Nevertheless, these increments are far lower than the national trends and the gap between national and regional human well-being is widening.

4.4.8 Livestock development in the 'Old agricultural frontier', Nicaragua

Livestock farming is considered to be one of the sectors that drive frontier farming through the large-scale conversion of natural habitats into pasture. This ongoing colonisation is affecting protected areas for biodiversity conservation in Nicaragua.

The case study focused on the livestock sector in the 'Old agricultural frontier': Boaco, Chontales and Matiguás. This area comprises 28% of the land area of Nicaragua in the central low mountains and the east Atlantic plains, which was originally covered with dense rainforest. The history of the area can be divided into three periods: the meat production boom in the 1950s to 1970s, the Sandinista war period from 1979 to 1993, and from 1994 the privatisation and immigration period, which continues today.

The case covers the period from 1993 to 2004, when the area was colonised by different types of livestock farms with diverging objectives and management capacities. Farm types range from poor peasant subsistence farming through intensive small farming and extensive farming to commercial farmers and big land owners. Three accessibility zones were determined on the basis of good, medium and bad road infrastructure, with accompanying good to bad social services and economic opportunities. The research method consisted of an in-depth analysis of the farming and household system. (Belli et al., 2006)

Biodiversity

Between 1950 and 2002 primary forest cover shrank from 41% to 9% of the land area, putting protected areas for biodiversity conservation in Nicaragua at risk. As a result of the Sandinista war, people abandoned farms and the area of secondary forest increased rapidly, stabilising at 21% land cover after the war. The remaining primary forest is fragmented and key species of mammals, amphibians and birds disappeared locally as forest fragments became too small to meet their minimum habitat requirements.

Production of goods

Livestock ranching drove the large-scale conversion of natural forest ecosystems into pasture. The pasture area increased from 38% to 66% of the land area between 1950 and 2002. Ranching is a low productivity system on medium to large farms.

Erosion and soil degradation reduced the fertility of the soil and overexploitation led to a 15% decline in agricultural productivity. Milk productivity fell by 36%, maize by 31% and beans by 28%. The economic loss was high: a US$21 loss per hectare per year for livestock, US$12 for maize and US$27 for beans. Moreover, the supply of bushmeat dried up.

Human well-being

GDP per capita increased by 5% from 1993 to 2004. In 2000 the level of inequality was high (GINI 60%). Human well-being was more or less stable (stagnated) in the area, but differed considerably between the good and bad access zones. The bad access zones lack social services (schooling and primary health care, equality of access to capital and markets), institutional capacity and local government.

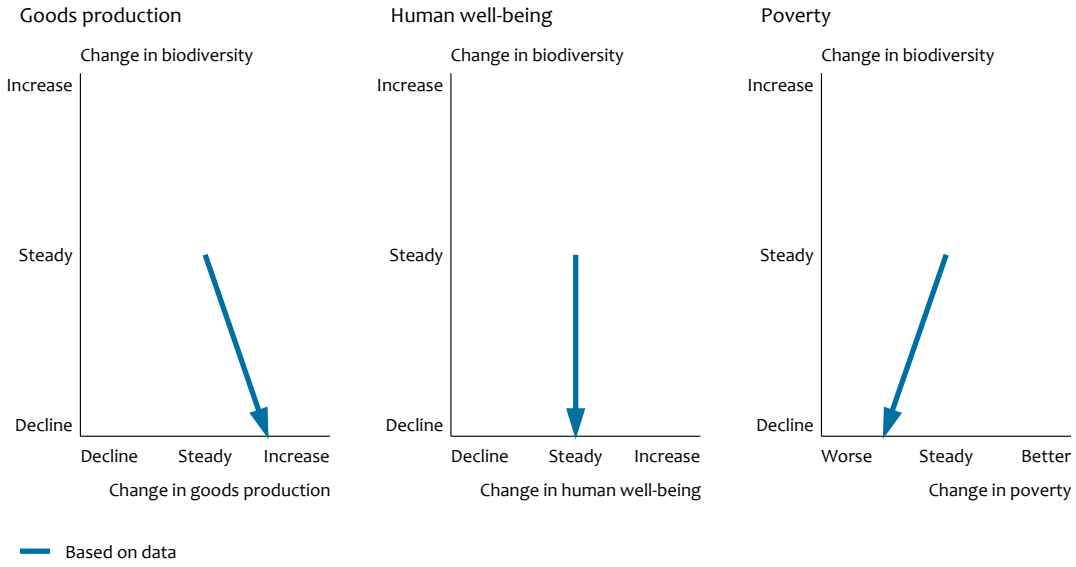
Poverty

Poverty is not an issue of hunger (daily intake is slowly increasing to about 2100 kcal), nor child mortality (which has decreased from 13% in the 1950s to 4% in 2000). However, the quality of the diet is decreasing as daily animal protein intake has fallen from 310 to 180 Kcal. Farms smaller than 50 hectares obtain an income under the Nicaraguan poverty line of US$284 a year. Large flows of poor immigrants from the populated mountain areas have been reported. These new migrants suffer from poverty as they establish their farms in remote areas, with no access to markets and social services. The number of poor people therefore increased.

Major causes of change are:

1. land use change with unclear ownership rights: land is in communal ownership, but can be 'sold' by the chief in charge. The control on trading of land is weak because of the complex traditional community based land ownership, and people buy and sell land without property titles;
2. low productive soil, brittle ecosystems: most of the land is not suitable for production. Erosion and soil degradation occur when soil cover is suboptimal and land use is beyond the carrying capacity. Heavy storms and hurricanes frequent the area and may affect ecosystems severely if they are in a bad condition;
3. unsustainable production management: because of their low investment capacity, new settlers rely on soil fertility built up naturally in the ecosystem. Minimum investments are made and large areas are needed to sustaining a living because of low productivity. The extensive livestock production system results from poverty. It coincides with low management and investment capacity, speculation on the future price of the land, lack of services and markets and lack of income opportunities elsewhere. The state reduced production support, and technical assistance to farmers was privatised. The agricultural development bank went bankrupt;
4. fragmentation of remaining natural ecosystems: at the landscape level, there is strong evidence from aerial photography that the original forests are suffering ongoing fragmentation;
5. poverty: poverty drives people to migrate to the agricultural/livestock frontier to obtain land. However, in these remote tropical plains, people suffer from social conflicts, lack of access to capital and markets, lack of social services such as schooling and primary healthcare, lack of institutional development and alternative production opportunities;
6. immigration of poor people and population growth: the population growth was on average 3.1% per year during the period 1993–2004. The population density increased from 7 to 23 people per km^2. Migration was planned by the government during the 1960s and 1970s, but later became spontaneous and uncontrolled;
7. market failures: two commercial systems are reported, the formal commercialisation chain towards export-oriented industrial meat and dairy production, and the informal uncontrolled sector for local and national consumption.

Biodiversity and socioeconomic indicators: Livestock in old agricultural frontier, Nicaragua 1993 - 2004 **Figure 4.7**



Biodiversity declined, production of goods increased, human well-being stagnated and poverty increased in the 'old agricultural frontier', Nicaragua during the period 1993–2004.

Prices in the informal sector tend to be higher than prices offered by industries. Quality standards are higher in the processing industry.

Relationship between poverty and biodiversity

The depletion of biodiversity due to land use change while poverty increased in the area indicate a lose– lose trend (*Figure 4.7*). The large immigration flow of poor people into the area led to an increase in poverty. If this immigration flow had not existed, poverty would have been reduced and there would have been a win–lose trend. Biodiversity loss is high compared with the gain in human well-being. The forest was cleared for low productive, low-income farms on soil that is sensitive to erosion. While biodiversity was depleted, human well-being in the area stagnated in the bad access zone, leading to a vicious cycle of increasing poverty, more forest logging, etc.

Storyline of a lose–lose trend:

The agricultural/livestock frontier expanding into brittle ecosystems, caused by population growth and poverty

Poor people from outside the area as well as young farmers from the area move towards the agricultural frontier and start extensive livestock production. Land is available for new livestock farmers, but access to areas of pristine rainforest or recently cleared land is bad, as is the suitability of the land for production. During the first decade after colonisation, income at the agricultural frontier was somewhat higher, as people benefited from hunting and gathering in the forest remnants. When extensive livestock ranging extended and continued, soils became depleted. Low management and investment capacity, speculation on the future price of the land, lack of services and markets and lack of income opportunities elsewhere cause new poverty. Livestock production on brittle soils causes high biodiversity losses and generates low incomes. Biodiversity loss continues until no more cheap land is available. This system is a poverty trap. Biodiversity loss was caused by poverty and leads to further poverty.

4.4.9 Mangrove in Giao Thuy, Vietnam

Mangrove forests offer a rich pallet of goods and services. They are under severe threat because they attract people in search of a living. Over the last fifty years the Giao Thuy district has experienced various changes in exploitation and economic development:

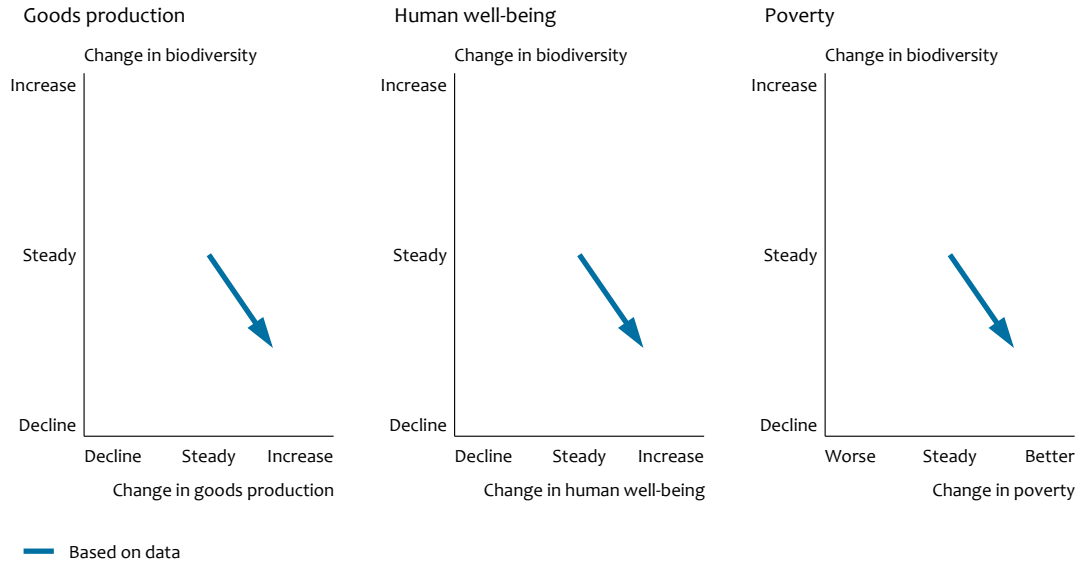
- Before 1960 it was a natural mangrove area extensively used by the local population.
- Starting in 1960 the mangrove forest was cleared for shrimp farming and in 1968 it was damaged by typhoons. Mangrove replanting started but the forests were destroyed again.
- During the 1980s the mangroves and fishing area were overexploited.
- From 1997 to 2004 mangroves were replanted.
- Recently, the mud plains have come under private exploitation.

The case study describes the period from 1995 to 2003. During this period the human population increased rapidly. The local communities cultivate the area inside the sea dike for paddy rice production and exploit the mangrove forest and coast. Some people who depend for their livelihood on the exploitation of the commons suffered from poverty as access to the commons became increasingly restricted. Shrimp pond farmers and concessionaires for mud-plain exploitation are relatively better off. (Nguyen Hong et al., 2006)

Biodiversity

In 2003, of the total area inside and outside the sea dike, 36% was in use for paddy rice cultivation, 5% for aquaculture and 12% was mangrove forest, including plantations. Biodiversity was lost due to intensive use of recently privatised mud plains

Biodiversity and socioeconomic indicators: Mangrove in Giao Thuy, Vietnam 1995 - 2003 **Figure 4.8**



Biodiversity declined, production of goods and human well-being increased and poverty declined in the mangrove exploitation district of Giao Thuy in Vietnam during the period 1995–2003.

for clam production and overexploitation of the mangrove forest. The MSA was 80% in the 1960s, dropping to 50% in the 1980s and 26% in 2003. The creation of mangrove protected areas and mangrove plantations supported conservation and restoration. All these processes together resulted in an overall biodiversity decline in the case area between 1995 and 2003. Natural ecosystems were increasingly overexploited.

Production of goods and services

Between 1995 and 2003 the production of goods increased. The production of shrimp in ponds increased at a rate of around 15% per year and clam production by 30% per year. Crab and shrimp catches increased at lower rates. The economic value of production increased from 2 to 3.7 million Vietnamese Dong (VND).

The stable area of high quality agricultural land located inside the sea dike is the main livelihood source, although 68% of households also fish by hand outside the dike. Between 1995 and 2003 the share of income from aquaculture increased from 17% to 29% and the proportion of the population involved in aquaculture increased from 6% to 14%.

The share of income from mangrove exploitation was 18% for poor people, 50% for the middle classes and 35% for the rich. Some additional income was obtained from the sale of honey, firewood and medicinal plants collected from the mangrove forest. Mangrove plantations provide effective protection against heavy storms and high tides and trap organic matter and mineral particles to form soils (mud plains).

Human well-being

The annual household income increased from VND2.5 to 3.5 million between 1995 and 2003. The GDP growth rate increased continuously, from 5% in 2000 to 8% in 2004, dropping temporarily to 3% in 2005 due to cyclone damage.

Poverty

Between 1995 and 2003 the poverty percentage (HPI) decreased from 20% to 10%, measured against the Vietnamese poverty line. The percentage of poor households dropped from 15% to 10% and hunger almost disappeared.

Major causes of change are:

1. the establishment of a protected area for the remaining mangrove forest, excluding access for local people and with management restrictions in the buffer zone;
2. restricted access to commons for hunters and gatherers due to increased shrimp farming and increased private clam farming;
3. further limitation of access to the mud plains due to mangrove plantations;
4. free access to the commons, causing competition between local hunters and gatherers with tourism and poor people from outside the area, in turn leading to overexploitation of the coastal area;
5. pollution of the mangrove;
6. human population increase;
7. national and international demand for marine products;
8. unequal distribution of natural resources among the population, with winners and losers.

Relationship between poverty and biodiversity

Biodiversity was lost due to overexploitation, intensification and expansion of production, while poverty was reduced: a win–lose trend (*Figure 4.8*). Fishermen and collectors put increased pressure on the mangrove. People who depended on the common natural resources for their livelihood suffered increasing poverty, caused by the lack of access to these resources and the reduction in the size of the area available to exploit following the establishment of the protected area, mangrove plantations and private ownership. The remaining natural resources were overexploited, exacerbated by increa-

sing exploitation of these resources by people from the cities. This indicates a lose–lose trend for one stakeholder group.

Storyline of a win–lose trend:
Livelihood dualism: competition between market-oriented and subsistence livelihoods with restricted access for the poor to natural resources
Mangrove/coastal exploitation in Giao Thuy is an example of livelihood dualism: people that have private land use rights alongside those that depend on the exploitation of the commons; relatively rich versus poor people; access or no access to natural resources and financial capital. The economy of the Vietnam mangroves is market oriented for those who obtained private user rights over shrimp ponds or mud plains for clam farming. At the same time, fishermen and gatherers use the coastal commons for their subsistence, the latter having few opportunities to escape poverty, although the contextual factors for the rural population as a whole are relatively favourable.

The inhabitants do not have equal access to the natural resources. The area of common land is reduced by privatisation, mangrove reforestation and the establishment of a protected area for biodiversity conservation. The gatherers also have very little access to financial inputs and technology, which may explain why pressure on the remaining freely accessible mangrove forest and buffer zones is very high.

The impacts on biodiversity are grave and impacts on human well-being, except equality, are positive for the mangrove area as a whole, but negative for the fishery and the gatherers. The prospects for the future of this community are negative because pressures on natural resources will remain high due to market demand for shrimps and clams, and because people from the cities increasingly use the commons for game fish and hunting. Floods and typhoons resulting from climate change as well as global market demands and price development will result in diverse threats and opportunities for the different livelihood groups.

4.4.10 Shifting cultivation in Dakrong, Vietnam

This case study deals with the tension between protected areas and traditional livelihoods of ethnic minorities. The study area is situated in the Dakrong district in the centre of Vietnam, along the border with Laos in a remote, thinly populated mountain area. Before the war, the mountains in Vietnam were covered with impenetrable primary forest. Large areas of these forests were destroyed during the war by spraying with Agent Orange and bombing. Additionally, soldiers cleared the forest around the North–South demarcation line, which runs through the case study area. After the war, the area was re-colonised by returning ethnic people and new immigrants. They started clearing landmines and began to exploit new areas of forest. The population of ethnic minorities increased rapidly.

There are three ethnic groups: two indigenous groups and one immigrant group. Two groups are subsistence based and pursue different livelihood strategies: a mix of shifting cultivation, forest use and farming on small plots of low productivity paddy rice. Hunting is a popular activity as a way of obtaining more food and protecting crops against damage by game. The immigrant community is also subsistence based, but produces more cash crops.

The case covers the period from 1998 to 2005. In 2002, the province implemented a development plan for the western part of the Dakrong district. The plan focused on strict protection of the forest and intensification of agriculture. During 2000–2005, several policies were enforced to improve the management of forest exploitation and prevent illegal trading in wildlife species. In 2005 the government created a protected area and planned a biodiversity corridor. Forest clearing and timber exploitation is not permitted in this area and the government promotes reforestation. (Truong Quang, 2006)

Biodiversity
The area of rich and medium rich forest decreased from 13,800 hectares in 1998 to 10,900 hectares in 2005, while the areas of poor forest and forest plantations increased. The forest cover increased, but the overall forest quality decreased because it was intensively exploited for hunting and gathering. The MSA in the case area dropped from 58% to 55%.

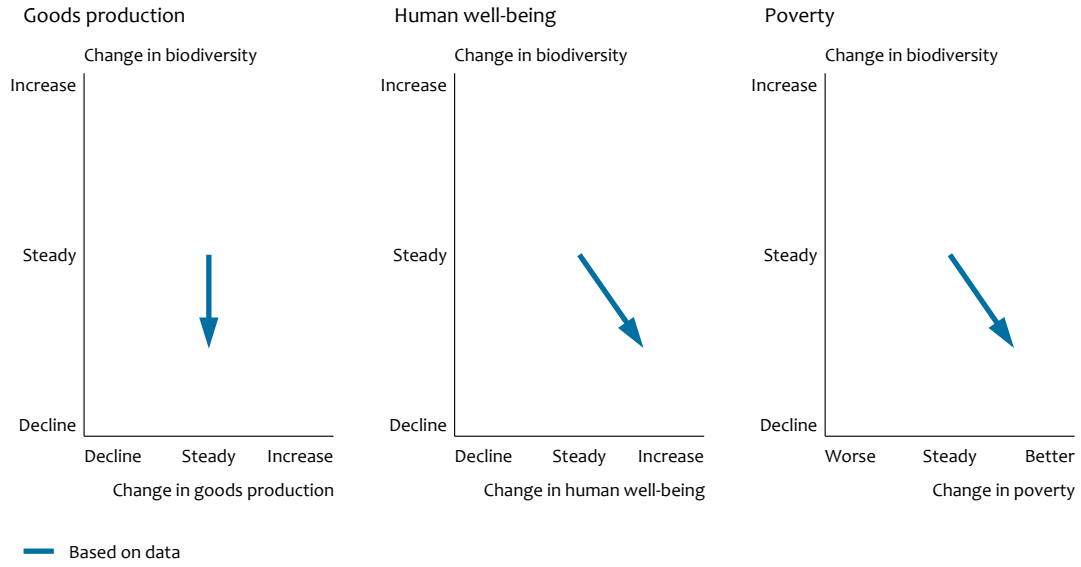
Production of goods
The local economy depends heavily on agriculture and forestry, which accounts for 90% of income. The proportion of total income provided by forestry and non-timber forest products fluctuated, but increased from 10% to 31% between 1998 and 2005. The forest was used for legal logging (increased 200–300%), illegal logging, collecting firewood (estimated to be six times as important as logging in terms of volume), legal wildlife hunting and poaching. The slash and burn agriculture caused some fire damage. The total exploitable timber stock in the Dakrong district decreased during the study period, while the area of natural forest remained almost the same, but the quality of the forest decreased. The agricultural area decreased. Although paddy rice production increased between 1998 and 2005 due to expansion of the irrigated area, productivity decreased by 25% because of bad management practices. Food production per capita varied considerably between localities, and seemed to increase overall, although at a lower level than the national average. Livestock numbers increased by 13% between 1997 and 2001.

Human well-being
Human well-being indicators for food production, healthcare and education showed a positive trend. However, the standard of living in Dakrong district was low compared with the national average, and the gap was not closing.

Poverty
The poverty rate decreased from 43% to 28% of the population between 1998 and 2005, but from 2005 became 66% as a result of the introduction of new standards (shifting baseline). In some communes, the rate was even higher than 70% according to the new standard.

Major causes of change are:
1. no access to new forest for clearance: the shifting cultivation system collapsed due to shortening of the fallow period and degradation of the soils;
2. the brittleness of ecosystems: the soils are sensitive to degradation because of the steep slopes and soil charac-

Biodiversity and socioeconomic indicators: Shifting cultivation in Dakrong, Vietnam 1998 - 2005 **Figure 4.9**



Biodiversity decreased, production of goods remained stable, and human well-being and poverty improved in the uplands of Dakrong district in Vietnam with shifting cultivation during the period 1998–2005.

teristics, and because the ecosystems do not regenerate easily;
3. the increase in paddy rice production due to expansion of the irrigated area, although productivity decreased;
4. low market integration: the ethnic minorities who originally inhabited the area practice shifting cultivation for subsistence, and access to capital and technology is low;
5. the dependence of the ethnic minorities on natural resources: their livelihood is culturally rooted, and their capacity to adapt to change is low;
6. decreased access to suitable land and forest for satisfactory performance of traditional practices: biodiversity protection policies restricted access to natural forest;
7. the high rate of population growth, more than 2% per year during the period 1998–2005: out-migration was almost nil because of the cultural background of the ethnic minorities;
8. the increasing use of the forest for food, materials and income: specific markets for non-timber forest products are well developed in comparison with crop production.

Relationship between poverty and biodiversity

Biodiversity was lost due to increased forest exploitation and production intensification, while poverty levels declined: a win–lose trend (*Figure 4.9*). People who depended for their livelihood on the collapsed shifting cultivation system became increasingly dependent on gathering in the common forests. They may suffer poverty as a result of overexploitation and resource degradation, while access to other forest areas was heavily restricted to protect biodiversity. The income shift from agriculture to forest use was the first sign of an emerging lose–lose trend.

Storyline for a win–lose trend probably shifting into a lose–lose trend:

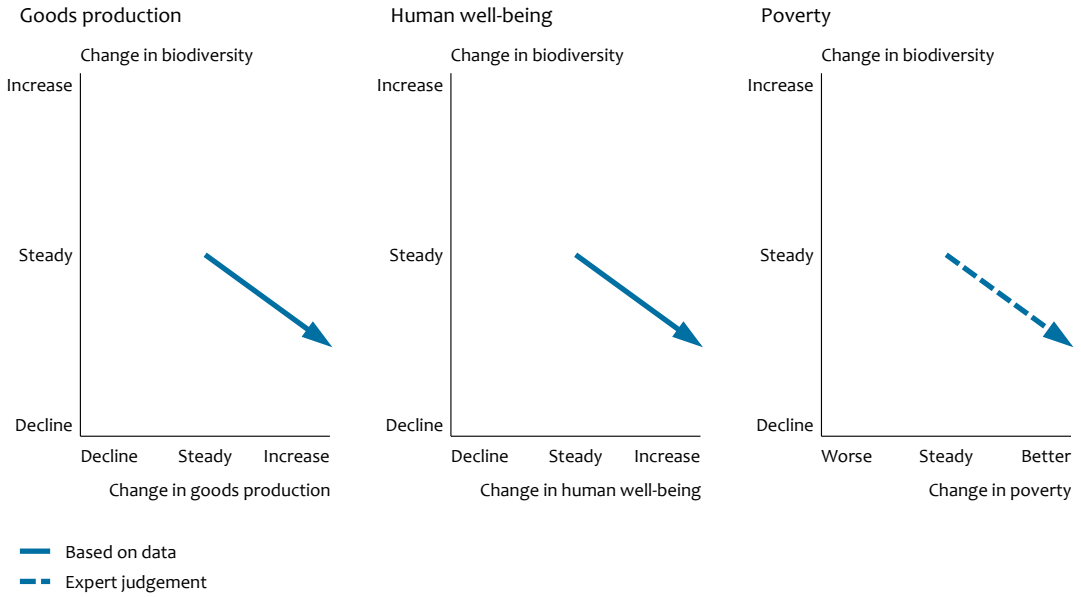
Collapse of shifting cultivation and failing government intervention, causing overexploitation of natural forest

The economy of the Vietnam uplands is subsistence oriented, with limited potential for poverty reduction because of the lack of market integration. In recent decades, productivity has decreased because of the shortening of the fallow period and degradation of the soils. No new land is available for shifting cultivation. Biodiversity is probably decreasing due to increasing hunting and gathering in the forests. Pro-biodiversity policies focus on protecting forests and prohibiting the conversion of forest into arable land or pasture for livestock production. Ethnic minorities receive support from the government poverty reduction programme, which is geared to introducing high yield rice varieties and extension services to support intensive agricultural farming, but land suitable for paddy rice production is very limited. The support also comes with special credit, education, and healthcare programmes for the poor. Such support should discourage the poor from destroying the forest, but forestry and other forest exploitation activities have increased rapidly because few livelihood alternatives are available.

4.4.11 Marine fishery in Ghana

The people of Ghana, both those living on the coast and those living inland, rely on fish as a source of protein. Poverty is severe and dependence on fish for food security is high. Ghana's marine fisheries can be divided into two categories: the subsistence-driven canoe fleet and the profit-driven industrial sectors. Marine biodiversity is threatened by the sizeable fishing industry and loss of biodiversity has repercussions for fishing. In turn, any reductions in fish harvests have implications for human well-being due to the heavy reliance on fish for protein. Factors that affect harvests most are profit, consumption rates and, indirectly, population density. A distinc-

Biodiversity and socioeconomic indicators: Marine fishery, Ghana 1966 - 1988 **Figure 4.10**



Biodiversity decreased, catch and human well-being increased and poverty probably decreased because of the marine fishery in Ghana during the period 1966–1988.

tion is made between the period 1966–1988, when the total catch increased, and the more recent period 1988–2003 when the catch stagnated. (Alder et al., 2006)

Biodiversity

Biodiversity decreased over the entire period. The Marine Trophic Index (MTI) was used as an indicator for biodiversity. The MTI showed a downward trend between 1960 and 2003: from 3.5 to 3.2 on a scale of 1 to 5. The national fish catch consisted mainly of small pelagic fish. The MTI indicated that small fish replaced larger fish in the marine ecosystem.

Production of goods

The total catch of the traditional canoe fleet increased from 50,000 tonnes in 1960 to 250,000 tonnes around 1988. Since 1988 catches have fluctuated around the same level. A catch of 50,000 tonnes was considered to be the maximum sustainable yield. From 1960 to 1980 the number of canoes dropped and then increased again to the 1960 level of almost 10,000 in 2003, of which half were motorised.

Human well-being

In the period 1960–1988 catch per capita increased from about 4 tonnes per 1000 persons to 18 tonnes, and from 1988 to 2003 decreased from 18 to 12 tonnes per 1000 persons. The total number of people working in the fishery sector increased from 65,000 in 1960 to 123,000 in 2000. Besides the local catch, Ghana imported increasing volumes of fish to meet the national demand. From 1988 to 2003 these imports reduced the national demand shortfall (demand minus supply) for fish, while consumption per capita increased from 16 to 26 kg per person per year.

Poverty

Rural poverty rate in the coastal areas was 45% in 2003. This rate was the second highest rural poverty rate in the savannah area. The case study report contains no information on trends.

Major causes of change are:

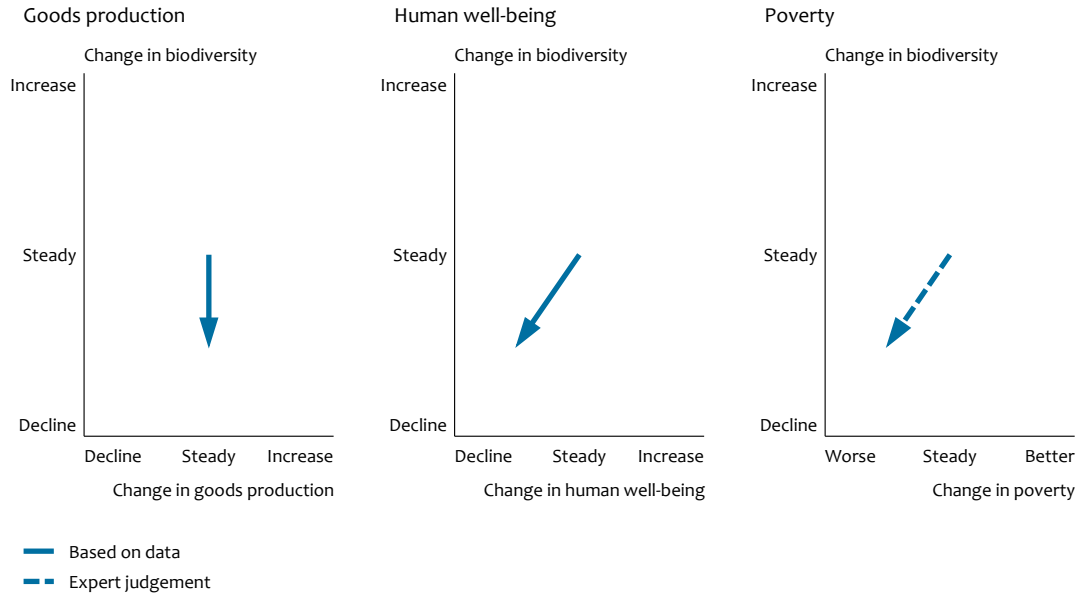
1. high population growth (3% per year from 1960 to 2003) by birth and migration to coastal areas;
2. government support for fish technology and credit;
3. high global demand for fish products and high prices on the market for fish;
4. poor law enforcement against illegal fishing techniques;
5. high incidence of poverty;
6. absence of employment outside fishing;
7. increasing imports of cheap fish;
8. pro-poor policies that promoted the increasing catches, the high catches in 1992, 2000 and 2003 all occurring in the year following a policy decision to stimulate Ghana's fisheries.

Relationship between poverty and biodiversity

In the period 1960–1988, the national fish catch rose to an unprecedented level. The consequence was a decline in biodiversity (lose) and growing catches per person, which increased human well-being and probably (this was not measured) decreased poverty: a win–lose trend (*Figure 4.10*).

In the period 1988–2003, the national fish catch remained at that high level, while the MTI indicator decreased further. The catch was considered to be far above the sustainable yield. Human well-being declined because of problems related to the rapidly growing population, and poverty probably followed this trend: a lose–lose trend (*Figure 4.11*).

Biodiversity and socioeconomic indicators: Marine fishery, Ghana 1988 - 2003 **Figure 4.11**



Biodiversity decreased, catch stagnated, human well-being declined and poverty probably increased because of marine fishery in Ghana during the period 1988–2003.

A decline or collapse of the total catch is expected, but has not yet occurred. This may be temporarily masked by the pro-fisheries measures: more effort was put into fishing.

Storyline of a win–lose trend shifting to a lose–lose trend: *More people and stagnation of production in the commons*

The economy of the Ghana marine fisheries is partly commercial and partly subsistence oriented. It has limited potential for poverty reduction and a mixed scores for contextual factors, but population density and growth are unfavourable. The social vulnerability of the fishery population is high because of poverty and a lack of alternative employment opportunities. Nevertheless, governance in Ghana is relatively good and favours the small-scale canoe fleet.

The impacts on biodiversity in the marine system are moderate because the traditional fishery concentrates on pelagic fish, but fishermen have recently started to diversify their catch. A further expansion of the fishery community and increased efforts to maintain catches above the maximum sustainable yield will probably result in a total collapse of the canoe fleet fishery system, with severe consequences for the people that depend on the exploitation of this resource for their livelihood.

4.4.12 Fishery in Lake Victoria, Kenya

Poverty and famine remain key challenges facing the rapidly growing population around Lake Victoria. After the introduction of Nile perch into the lake in the 1950s and the fishery boom in the 1970s, immigration caused a rapid expansion of the population around Lake Victoria. The number of canoes increased from 11,000 around 1980 to 19,000 in 1987. Besides the fish catch for local and national consumption, production expanded for export to foreign markets, leading to the establishment of processing factories, which were often financed by donor aid. The fish catch increased from 25 million kg per year in the 1970s to 200 million kg per year in the 1990s, but declined thereafter as the fish stocks were reduced. The CPUE (catch per unit of effort) showed a strong decline.

Lake Victoria also suffers from other impacts that indirectly affect human well-being: pollution from to lakeshore urbanisation and sedimentation caused by erosion in the catchment area, wetland conversion, such as large-scale drainage of swamps, and expansion of the invasive species water hyacinth into the shallow areas of the lake. The period described by the case study covers the period 1990–2000, with the situation around 1970 as a reference. (Manyala & Abila, 2006)

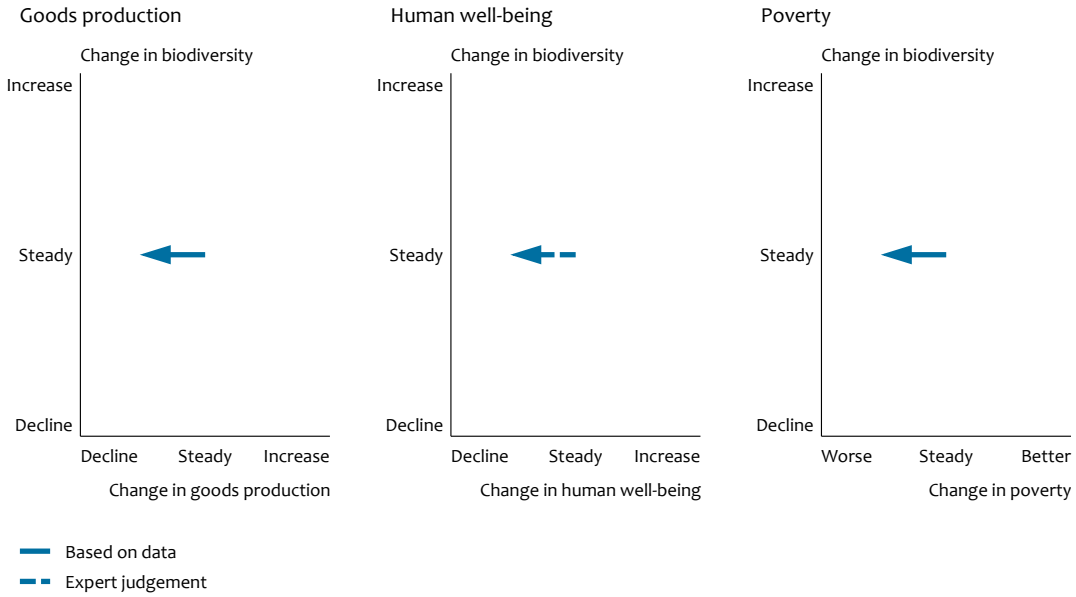
Biodiversity

Nile perch was introduced as an exotic species. In the period 1968–1970, before the Nile Perch boom, the calculated species diversity was 0.35 according to an indicator used by the local research group. This score is assumed to represent a 'natural baseline'. In the period 1981–1990 the index was 0.09 and increased gradually to 0.11 around 2000, representing a severely disturbed situation. Biodiversity improved because the Nile perch, which destroyed the original ecosystem first, was then (over) exploited. Original species have returned, but are present in very low numbers.

Production of goods

The total catch increased from 25 million kg per year in the 1970s to 200 million kg per year in the 1990s. Other data report a maximum of 380 million kg total catch in 1989, followed by a slight decline with major fluctuations. During the case study period the estimated maximum sustainable yield level of 213 million kg per year was exceeded. Since the 1990s the catch of Nile perch has declined and the factories started to process other fish, such as Tilapia and sardines, which toge-

Biodiversity and socioeconomic indicators: Fishery in Lake Victoria, Kenya 1990 - 2000 **Figure 4.12**



Biodiversity stayed about the same, catch declined, human well-being probably declined too, and poverty increased among fishermen at Lake Victoria, Kenya during the period 1990–2000.

ther with Nile perch made up 98% of the fish stock. The catch per unit of effort (CPUE) declined from 22 million kg per boat in 1989 to 8 million kg per boat in 2000. Mesh size declined and so did the average size of the fish caught. In 2000 the total value of the fishery sector was US$550 million (US$250 million for export), providing employment for 180,000 fishermen and 600,000 fish traders, with 7 million people dependent on the sector.

Human well-being

Between 1990 and 2000 catches per boat per day halved and sometimes even fell to one sixth and incomes declined accordingly. Nile perch destined for factory processing yielded more profit than catches for other markets.

Poverty

Between 1990 and 2000 the incomes of fishermen decreased and were not adequate to meet daily family needs. In 2006, 60% of the fishermen's families had inadequate food.

Major causes of change are:

1. the introduction of Nile perch;
2. high national and global demand for fish;
3. overfishing and overcapacity of the processing industries;
4. high population growth;
5. pollution of the lake, wetland conversion and water hyacinth invasion;
6. political neglect of the Lake Victoria region;
7. poor capacity of boat owners and fishers to make good use of the profits being made, with inadequate provisions to put aside savings to invest later on, and most profits going to the processing industry;
8. low level of organisation and social cohesion among fishers and boat owners.

Relationship between poverty and biodiversity

From 1970 to 1990 biodiversity in Lake Victoria decreased sharply, caused by the Nile perch boom and increasing fish catches, sometimes far above the maximum sustainable yield. These high total catches were achieved by an increase in the numbers of fishermen and boats, a higher catch per unit effort (CPUE) and changing fish species composition in the lake. Large numbers of poor people from elsewhere moved to the lake and, besides fishing, they also started small farms around the lake. A hundred thousand extra fishermen were employed and their well-being was probably improved, although there is no information about the poverty situation during this boom period. Between 1990 and 2000 biodiversity in the lake stayed at about the same very low level, while the catch from the lake and human well-being levels declined and poverty increased: a lose–neutral trend (*Figure 4.12*).

Storyline for a lose–neutral trend, tending towards a lose–lose trend:

Poverty caused by rapid population growth, while biodiversity in the commons is at a very low level

The economy of Lake Victoria is partly commercial and partly subsistence oriented. It has limited potential for poverty reduction because of overfishing, pollution, and a growing population of new poor immigrants from the hinterland. Governance levels in Kenya are weak and only a few pro-poor policies are known. The impacts on the freshwater ecosystem are difficult to assess, but biodiversity seemed to be stable between 1990 and 2000. The introduction of Nile perch in the 1950s decimated the original fish populations and the biodiversity of the lake. Nowadays, because of overfishing of the Nile perch, stocks of the original fish species have stabilised, although at a very low level. Although Nile perch fishing provided a new income opportunity for poor people for a certain period, it also attracted more poor people from the

hinterland. Limited investments were needed to start fishing, profits were high and catches could be sold for cash immediately after fishing. Local people do not benefit equally from the profits of the fishing industry. The prospects are quite negative, also for the Nile perch fishery.

5 Determinants, patterns and mechanisms

In Chapter 4 we identified already 11 causes of change that were relevant for one or more cases. In this chapter we deduce determinants that are relevant for all cases from the 34 input indicators that were chosen to characterise the context, resources and resource use system (section 3.4 and Annex 2). These determinants will help to analyse new cases faster because they allow us to focus directly on the relevant characteristics. Also, we expect that the value patterns of the determinants will give insight into generic mechanisms of change.

Section 5.1 deals with the selection of the determinants. Determinants are those input indicators that determine to a large extent the change in biodiversity and poverty. In section 5.2 the cases are clustered into 4 groups that have similar value patterns of determinants. The aim is to find determinant-value patterns that are connected to win–win, lose–lose or intermediate outcomes for trends in poverty and biodiversity. From these patterns we deduce the mechanisms in section 5.3.

5.1 Selection of determinants

With our research partners we selected 34 input indicators to describe the contexts, resources and resource use systems in the cases. These input indicators were considered relevant by at least one of the research teams, either from the literature or from experience. We asked the research teams to score these input indicators on a scale of 1 to 5, indicating an unfavourable to favourable situation for poverty reduction.

The 5 input indicators belonging to 'market integration' and the 6 input indicators belonging to 'governance' were combined by averaging these indicators to obtain one score for 'market integration' and one score for 'governance'. Nine input indicators were deleted for the following reasons:

- Several partners indicated that information on the following topics was unsatisfactory:
  - - policies for stimulating diversification of production systems in the focus area (1.3.3);
  - - policies for stimulating added value and off-farm employment (1.3.4);
- diversity of products by dominant actor type (3.3.2).
- Some input indicators concerned two causes that were already addressed separately:
  - - expansion versus intensification by dominant actor type (3.3.3);
  - - natural versus capital management inputs by dominant actor type (3.2.3); we kept the input indicators 'access to natural resources' (3.2.1) and 'access to financial capital' (3.2.2).
- Some input indicators reflected outcomes more than causal factors:
  - - proportion of remaining ecosystems with original biodiversity in focus area (2.1.1);
  - - rate of recent land use change in the focus area (2.1.3);
  - - level of human well-being in the focus area (2.2.2);
  - - incidence of hunger in the focus area (2.2.3); the input indicator 'level of poverty in the focus area' was retained (2.2.1).

This resulted in 16 determinants, which are listed in *Table 5.1*. Together they describe the state of the several stages in the conceptual framework (*Figure 5.1*) and may determine the actual change in biodiversity and poverty. They correspond to causes of change described in the literature and found in the case studies (sections 2.1 and 4.14).

5.2 Determinant patterns

First, the cases were clustered into three groups based on input indicators, using the statistical method 'K-means clustering'. This analysis resulted in one large group, one small group and one exceptional case (*Table 5.2*).

Regarding the outcomes (poverty-biodiversity trend), the Mali case was included in the group with Brazil and Indonesia because it has a similar pattern but both lower values for the outcome indicators and it concerns an export oriented crop (cotton), like soy and palm oil. We divided the rest of group A into cases with a lose trend for poverty and cases with a win or neutral trend for poverty. This resulted in the 4 groups shown in *Table 5.3*. Mexico was added to the group with a lose trend for poverty, but because of the strong government intervention, lower initial poverty level and higher employment opportunities, it could just as well be combined and compared with the Costa Rica case.

Determinants of poverty and biodiversity

Table 5.1

Determinants	Term in framework
1.1.1 Absolute population density (inhabitants per km²)	Population density
1.1.2 Rate of population change (% per year)	Population density change
1.2 Governance (average of 6 indicators): *1.2.1 Level of corruption* *1.2.2 Level of inequality* *1.2.3 Level of voice and accountability* *1.2.4 Level of rule of law* *1.2.5 Level of political stability/violence* *1.2.6 Level of government effectiveness*	Governance
1.3.1 Policies stimulating expansion of production systems	Expansion policies
1.3.2 Policies stimulating intensification of production systems	Intensification policies
1.3.5 Policies stimulating protection of natural ecosystems	Biodiversity protection
1.4 Level of integration in national or global markets (average of 5 indicators): *1.4.1 Integration in national or global markets* *1.4.2 Growth potentials commodities* *1.4.3 Long-term profitability commodities* *1.4.4 Value added by primary and secondary processing* *1.4.5 Power concentration in market chain*	Market integration
2.1.2 Susceptibility of ecosystems to environmental degradation	Brittleness
2.2.1 Level of poverty in the focus area (vulnerability to poverty)	Level of poverty
2.2.4 Employment opportunities in and around the focus area	Employment opportunities
3.1.1 Dominant actor type in terms of production volume and area	Dominant actor type
3.2.1 Access to natural capital by dominant actor type	Access to natural resources
3.2.2 Access to financial capital by dominant actor type	Access to capital
3.3.1 Labour productivity by dominant actor type	Labour productivity
3.3.4 Productivity per unit of land or resource by dominant actor type	Land productivity
3.3.5 Level of capacities and skills by dominant actor type	Skills, management capacities

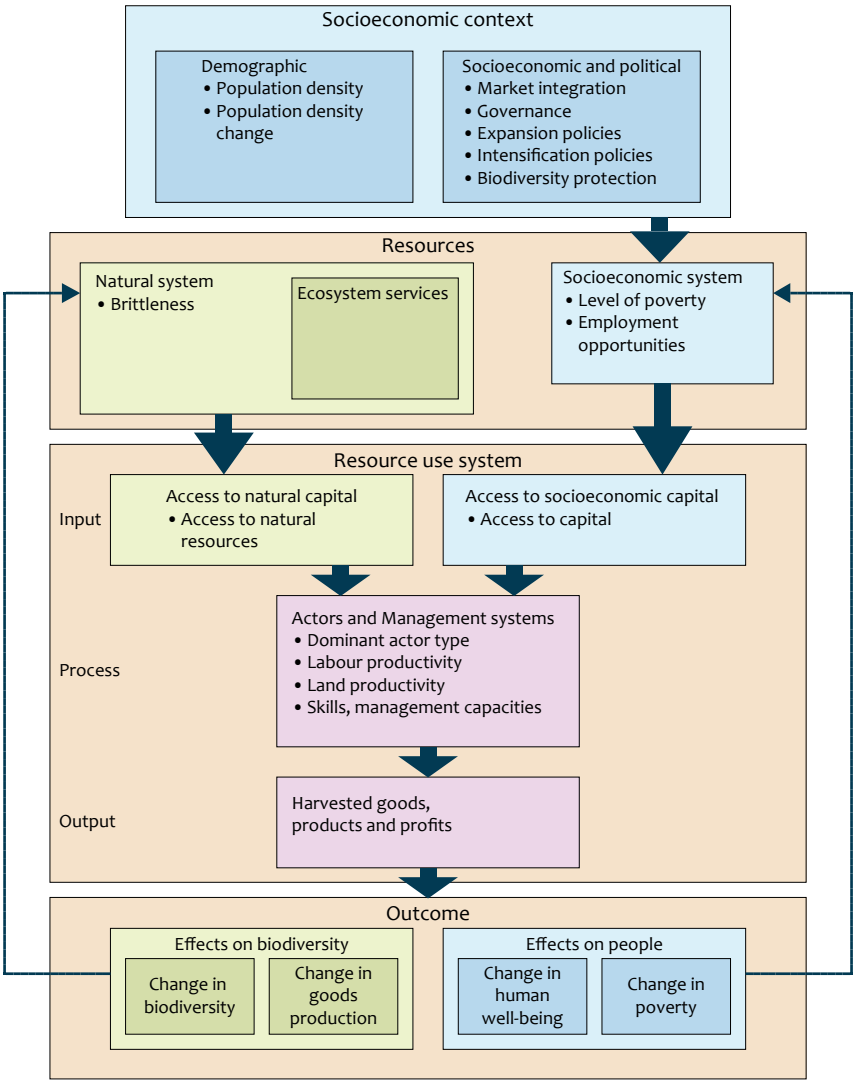
The numbers of determinants correspond with indicators in Annex 2.

Results of the cluster analysis to produce three groups of cases based on the determinants

Table 5.2

Case	Group, based on determinants	Biodiversity–poverty trend
Mali	A	Win–strong lose
Mexico	A	Lose–neutral
Nicaragua	A	Lose–strong lose
Vietnam mangrove	A	Win–lose
Vietnam upland	A	Win–lose
Ghana	A	Lose–lose
Kenya	A	Lose–neutral
Ecuador	A	Neutral–lose
Brazil	B	Win–strong lose
Indonesia	B	Neutral–strong lose
Costa Rica	C	Win–win

Results of the K-means cluster analysis to produce three groups of cases (A, B and C) based on the determinants (input indicators)



Position of determinants in the conceptual framework.

5.2.1 Win–strong lose or neutral–strong lose trends with high market integration and access to capital

Three cases are characterised by a win–strong lose trend or neutral–strong lose trend: Brazil (soy), Mali (cotton) and Indonesia (palm oil) (*Figure 5.2*). They have high market integration and high access to finances in common, together with strong expansion policies. Except for Mali, all economic determinants have favourable scores.

Mali follows the same pattern as Brazil and Indonesia, but the scores for economic determinants are lower. The process is probably similar, but with a different dominant actor type. The dominant actor type for cotton production is of local origin, semi-commercial and relatively small-scale in comparison with the corporate type for soy and palm oil.

There are more differences between the determinants of the cases:

- Indonesia has the least favourable scores on governance and intensification policies.
- Indonesia has a high population density and Mali a high population growth rate. These possibly explain the less favourable outcome and prospects for poverty reduction than in the Brazil case.
- The best market potentials are for soy in Brazil and palm oil in Indonesia; the market potential for cotton in Mali is limited.
- Mali has a higher level of poverty than Brazil and Indonesia.
- Access to natural resources is favourable in Brazil and Indonesia, and less so in Mali.

5.2.2 Lose–lose and lose–neutral trends

Nicaragua and Ghana 1988–2003 show lose–lose/strong lose trends and Lake Victoria in Kenya and Mexico lose–neutral trends (*Figure 5.3*). Most of the economic determinants have low scores: alternative employment opportunities are scarce, skills and labour productivity are low, population growth and initial poverty level are high and ecosystems are brittle. Selective catch of the alien species Nile perch in Lake Victoria has

Clustering of cases into four groups

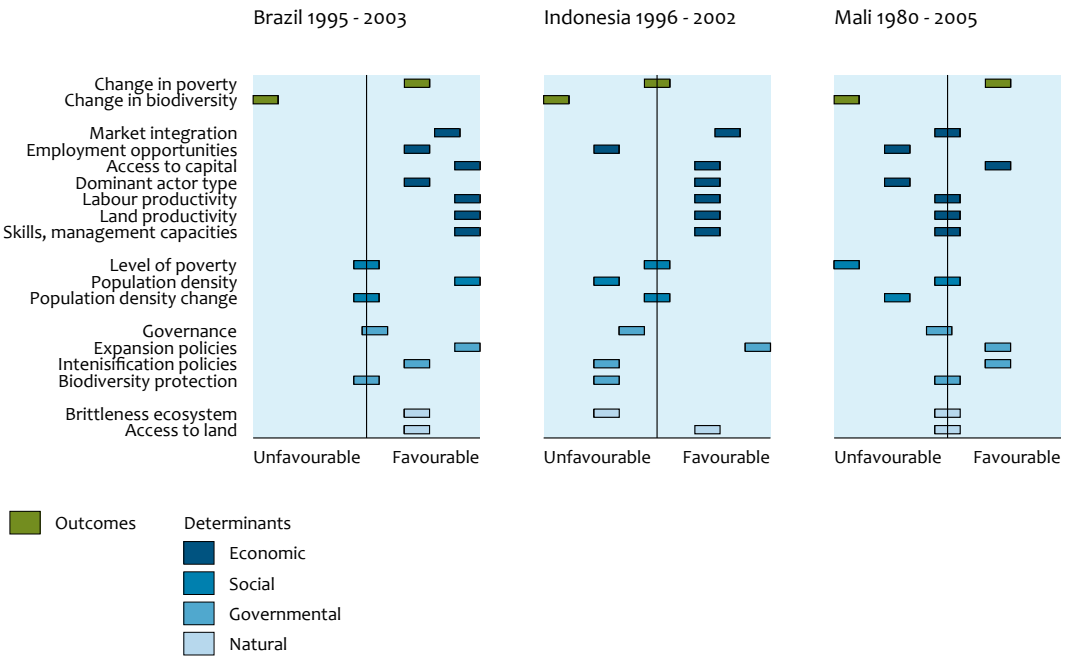
Table 5.3

Case	Poverty–biodiversity trend	Distinguishing determinants
Brazil	1. Win–strong lose	High market integration, access to capital, expansion policies
Mali	1. Win–strong lose	Moderate market integration, high access to capital, expansion policies
Indonesia	1. Neutral–strong lose	High market integration, access to capital, expansion policies
Nicaragua	2. Lose–strong lose	Fast population growth, low skills and productivity, high poverty level, brittle ecosystems
Ghana 1988–2003	2. Lose–lose	Fast population growth, low skills and productivity, high poverty level, brittle ecosystem
Kenya	2. Lose–neutral	Fast population growth, low skills and productivity, high poverty level, brittle ecosystem
Mexico	2. Lose–neutral	Fast population growth, low skills and productivity, moderate poverty level, moderately brittle ecosystems
Vietnam upland	3. Win–lose	Low market integration and access to capital, high population density, brittle ecosystems
Vietnam mangrove	3. Win–lose	Low access to capital, high population density, brittle ecosystems
Ecuador	3. Neutral–lose	Low market integration and access to capital, high population density, brittle ecosystems
Costa Rica	4. Win–win	Strong government interference and biodiversity protection, low poverty level

Clustering of cases into four groups based on the outcome indicators combined with the value patterns of determinants

Outcomes and determinants of win - lose and neutral - lose trends, international market oriented

Figure 5.2

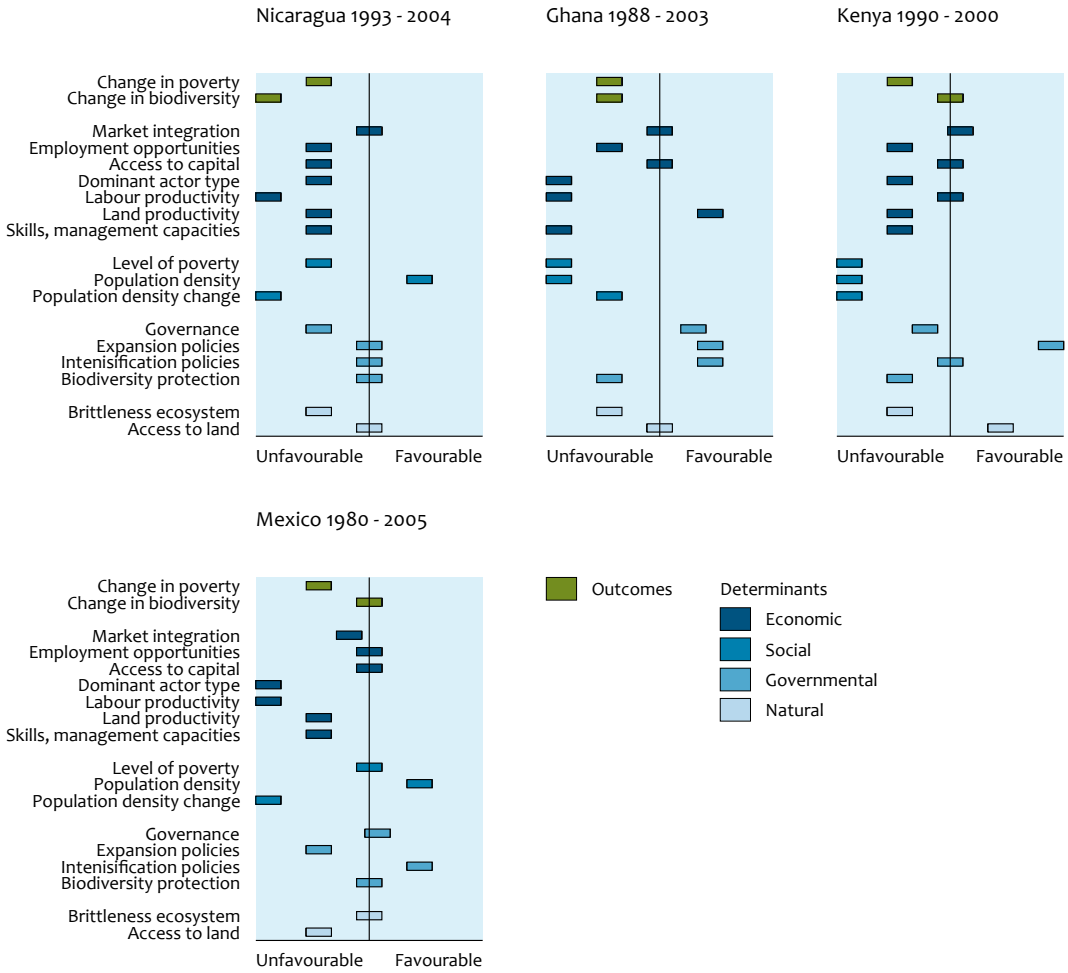


Determinant values for cases with high market integration, high access to finances and strong expansion policies: win/neutral–strong lose trends.

favoured the original species, but at a very low abundance, which explains the 'neutral' trend for biodiversity change. Biodiversity policies (no-access to forests) in combination with subsidies on agricultural production probably explain the 'neutral' trend in biodiversity change in Mexico. Dominant actors are subsistence to semi-commercial farmers or fishermen. Integration into markets and access to natural resources are moderate. Although natural resources are available and accessible, production is not enough to keep pace with population growth.

Expansion and intensification policies exist in all four countries, but do not succeed in reversing the negative trend. The combination of bad socioeconomic and ecological conditions and moderate to weak policies are conditions that create poverty traps. The main differences between the Mexico case and the other cases in this group are better employment opportunities, a lower poverty level and a less brittle ecosystem in Mexico.

Outcomes and determinants of lose - lose and lose - neutral trends **Figure 5.3**



Determinant values for cases with low market integration and rapid population growth: lose–lose/neutral trend.

5.2.3 Win–lose or neutral–lose trends with low access to capital

Win–lose trends and a neutral–lose trend are found in the two Vietnam cases and in Ecuador respectively (*Figure 5.4*). The main difference with the cases described in section 5.2.1 is that access to financial and natural capital is low for this group and high for the cases in group 1. For Vietnam upland and Ecuador, market integration is also low, with low value added, low power concentration in the market chain, low skills and productivity and few employment opportunities. For Vietnam mangrove, market integration is moderate, but not for all actor groups. As a result, all economic determinants have unfavourable scores. The dominant actor type is subsistence based. Population density and poverty level are high.

The fact that ecosystems are brittle worsens the situation. All these cases tend towards overexploitation of natural resources as the extent of the resources is limited. In Ecuador and Vietnam upland this may lead to a shift towards a lose–lose trend in future. In the Vietnam mangrove case, overexploitation and a lose–lose trend exists for one of the actor groups. The difference between these cases and those with a lose–lose trend (section 5.2.2) seems to be the stage of the process. Without intervention, if determinants stay the same and the processes continue these cases will turn into lose–lose trends.

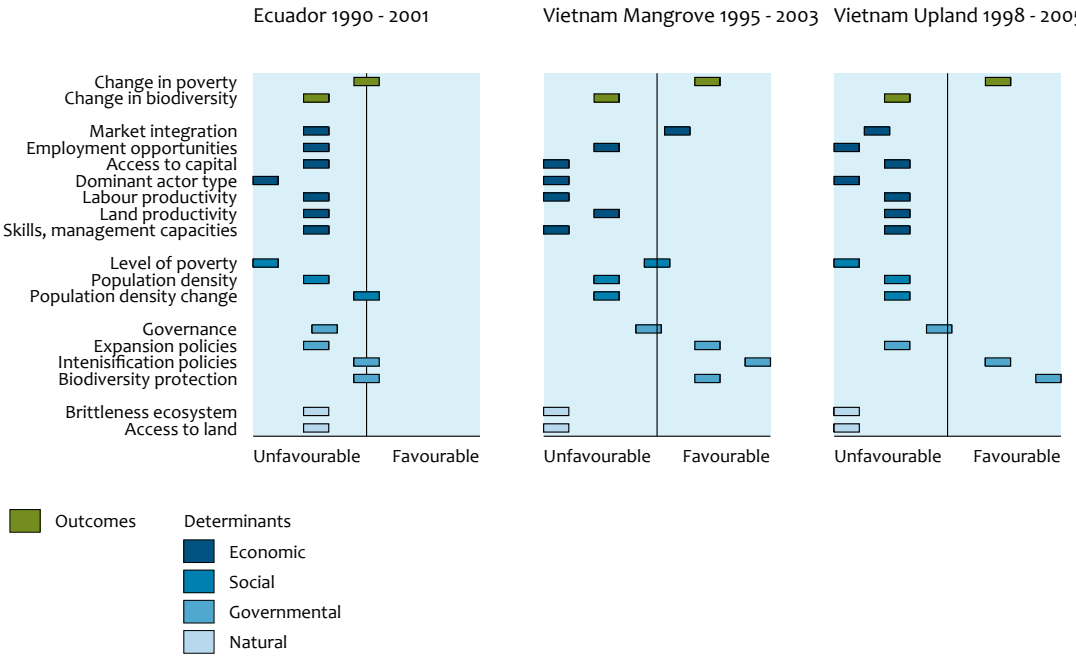
5.2.4 Win–win trend

Costa Rica is the only case with a 'win–win' trend for poverty and biodiversity change (*Figure 5.5*). Of all the cases it has the lowest initial poverty level and has a positive score for population density change, governance, intensification policies, biodiversity protection and most of the economic determinants. Emigration led to a decrease in population size. This, together with support from the government (reforestation programmes and payments for environmental services) are key factors for a double positive trend. This case differs from the win/neutral–strong lose cases (section 5.2.1) because of its favourable governance, strong biodiversity protection and medium expansion policies. Both groups have high scores for economic determinants in common.

5.2.5 Concluding remarks on determinant patterns

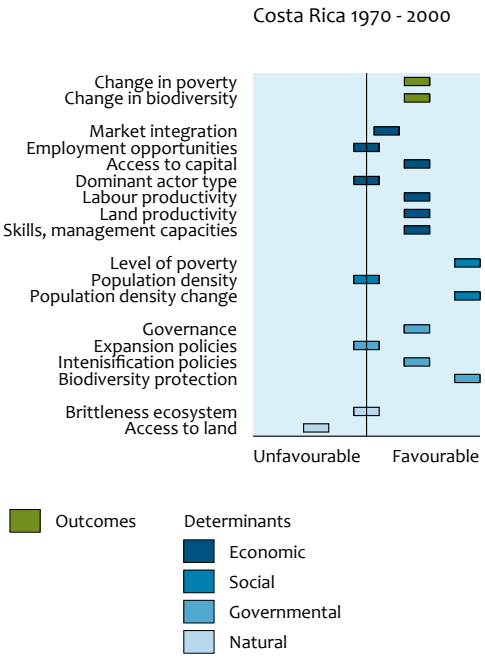
Two groups of cases have clearly distinctive determinant patterns: those that are highly market oriented with a 'win/neutral–strong lose' trend, and those with strong government interference and a 'win–win' trend. Market integration

Outcomes and determinants of win - lose and neutral - lose trends, low access to capital **Figure 5.4**



Determinant values for cases with low market integration and low access to capital: win/neutral–lose trends.

Outcomes and determinants of win - win trend **Figure 5.5**

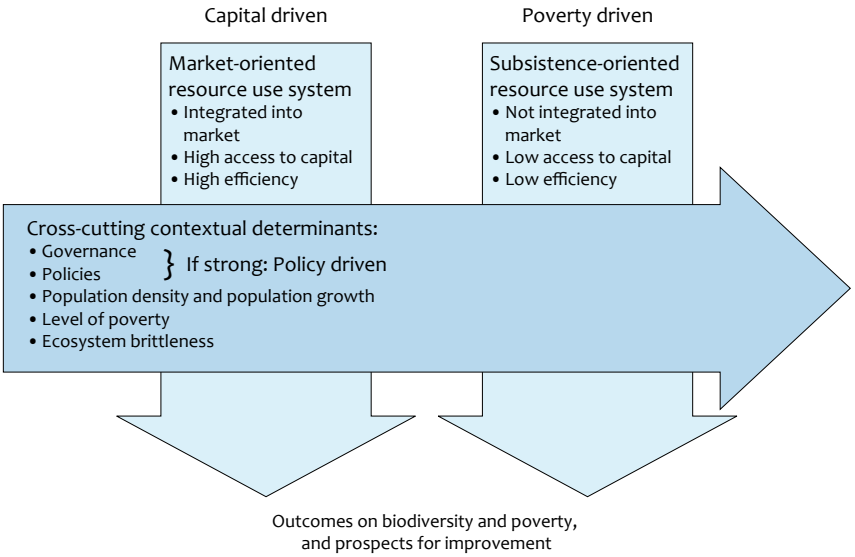


Determinant values for a case with strong governance and biodiversity protection: win–win trend.

indicators belonging to the resource use system and government policies are the major determinants.

For the other cases, the distinction between the groups is less clear. Market integration and resource use system determinants are less favourable for all cases, as are population density and/or growth rate, and initial poverty level. The difference between a win/neutral–lose trend and a lose–lose trend cannot be explained by different values of the determinants. Time is also an important factor. The difference seems to be in the stage of the socioeconomic processes and period of exploitation. As soon as population growth exceeds

Characteristics of the major mechanisms of change **Figure 5.6**



Major mechanisms of change are the drivers capital, poverty and policy.

production growth or access to natural resources becomes limited, the trend shifts from win–lose towards lose–lose. Government interference differs, but is not or not completely successful for all cases.

Different development processes that result in different patterns of determinant values can lead to similar changes in poverty and biodiversity. Win–lose trends can be found for highly market-oriented production systems (Brazil, Mali), but also for subsistence-based production systems (Vietnam upland and mangrove). A 'neutral–lose' trend instead of a win–lose can also be the outcome for a highly market-oriented production system, but with unfavourable governance and population density (Indonesia). Strong biodiversity loss goes with high market integration, high access to capital and strong expansion policies (Brazil, Indonesia and Mali), but also with semi-commercial farming in brittle ecosystems and rapid population growth (Nicaragua). The two cases with a lose–neutral trend have different causes for the neutral trend in biodiversity change (Mexico and Kenya). The subsistence-based production systems show win–lose, neutral–lose and lose–lose trends.

5.3 Mechanisms of change

To order the variation in determinant – outcome combinations, we distinguish three mayor mechanisms of change: capital driven, poverty driven and policy driven mechanisms. Market integration, access to capital, management skills and productivity are determinants that divide the cases into two broad groups (*Figure 5.6*): *market-oriented* resource use systems that are *capital driven*, with high scores for these determinants (group 1 described in section 5.2.1); and *subsistence-oriented* resource use systems that are *poverty driven*, with low scores for these determinants (groups 2 and 3 described in sections 5.2.2 and 5.2.3). Market integration offers opportunities for generating income and reducing poverty. Regeneration of degraded areas and nature conservation depend on the ban on expansion of the production area and the efficiency of the production system.

Whether this leads to actual poverty reduction depends on cross-cutting determinants, which are associated with the socioeconomic context of the resource use system. The determinants are: governance, policies on poverty and biodiversity protection, and population density and growth. Strong governance and policy interventions may shift negative trends on poverty and biodiversity in a more positive direction, but they may also cause dependency on government support. These resource use systems are *policy driven* ('group' 4 Costa Rica described in section 5.2.4 and Mexico in group 2 that could just as well be classified as group 4 if more emphasis was put on the determinants 'governance' and 'policies').

Policies are limited by the available budgets (from outside the focus area) and their success depends on factors like governance, population growth and ecosystem features (fertility, brittleness). Obviously government interventions have been more successful in Costa Rica then in Mexico. Weak governance and lack of policies in a market-oriented, capital-driven system may lead to high biodiversity loss without poverty reduction as in the Indonesia case.

In all three mechanisms, population dynamics are a dominant factor for both the poverty and biodiversity outcomes. Most of the subsistence-oriented cases tend towards overexploitation of natural resources, driven by high poverty levels, population densities and growth, combined with low financial and management inputs. If these processes continue in the same way, this will eventually lead to degradation of natural resources, decreasing productivity and increasing poverty: a lose–lose trend.

The brittleness of the ecosystem is an important cross-cutting factor too. If natural resources are abundant and brittle in capital-driven systems, this leads to strong expansion of production and a vast loss of biodiversity. In poverty-driven systems, fast population growth and little management input may have the same effect. If the limits of expansion are reached, either production is intensified, with the risk of overexploitation if ecosystems are brittle, or people and production leave the area.

The three mechanisms should be considered as 'prototypes'. In practice, pure capital, poverty or government-driven cases are rare. Interaction between mechanisms within the same area is more likely.

6

Findings, conclusions and further reflections

Our research questions were:
1. How are biodiversity and poverty related under different conditions?
2. What indicators and what values of these indicators determine this relationship?
3. What mechanisms explain this relationship and indicator values?

In this chapter we first describe the findings and conclusions on these questions (sections 6.1 and 6.2). This is followed in section 6.3 by a discussion and further reflection on biodiversity–poverty relationships as a contribution to developing a theory that explains developments under different conditions. Finally, in section 6.4 we make some recommendations on further research.

6.1 Relationship between poverty and biodiversity

6.1.1 Findings

In nine out of eleven investigated cases, increased goods production is accompanied by declining biodiversity and vice versa: win–lose, lose–win or neutral–neutral trends. This is the relationship we would expect. An explanation for the deviant relationship in the other cases is that pressure put on the ecosystem for goods production exceeds the carrying capacity of the ecosystem. Ecosystems may be brittle and input from the production system may be too low to compensate for losses caused by harvesting. If the limits of expansion are reached, the ecosystem degrades and production stagnates or decreases. The two fishery cases and the Vietnam upland case are examples of production systems in this situation.

Increasing goods production is expected to improve overall economic conditions and human well-being, leading to a decrease in poverty. We find this relationship in four out of eleven investigated cases. Apparently, there are factors that hamper the passing on of profits from production to human well-being in the other cases. There are two reasons for this:
- Rapid population growth, inequality or a combination of both mean that less goods or profits are available per person or for groups within the population (Ghana 1988–2003 case, the Vietnam cases, Ecuador case).
- Profits from goods are exported from the case area and country (Indonesia case).

In some cases, human well-being improves more than the levels of goods production would suggest, due to:
- government intervention combined with emigration of (poor) people from the case area (Costa Rica and Mexico cases);
- a delay in reaction at the threshold of a shift towards a lose–lose trend when expansion of the production area reaches its limit at the boundaries of protected areas or because of the shift towards illegal (not measured) hunting and gathering in forests (the collapse of shifting cultivation in the Vietnam upland case).

6.1.2 Conclusions

If common natural resources are abundant and accessible, either large-scale commercial exploitation for international commodities or a rapidly growing population in search of new land to bring into cultivation – or, in aquatic systems, low investment livelihoods – may lead to strong expansion and biodiversity loss. In the analysed cases this did not lead to a proportional reduction in poverty. Profits were exported from the case area or had to be shared between an increasing number of people.

If access to natural resources becomes limited and the population keeps on growing, people intensify production and natural resources become overexploited, especially when they are brittle. This leads to win–lose trends for poverty and biodiversity, with a risk that they turn into lose–lose trends. If poor people migrate out of the area, the trend may become neutral–lose. If biodiversity is at a minimum, the trend is lose–neutral.

If there is strong government intervention with biodiversity protection, alternative employment possibilities, subsidised jobs and emigration, negative trends can be changed. If interventions are not strong enough, the trends do not improve. If interventions do not structurally improve the production system, but only addresses basic services like health care and education, human well-being may improve, but poverty remains. Subsidies on production may even hamper progress if this is invested in expansion of production area and not for improving agricultural techniques and management, leading to stagnation in productivity and profitability.

6.2 Determinants and Mechanisms

6.2.1 Findings

A set of 16 'determinants' were found that characterise the cases and the processes that drive the changes in biodiversity and poverty. We divided the eleven cases into four groups according to the values of these determinants and changes in poverty and biodiversity:

1. Cases that are highly oriented to international markets with high access to capital, leading to a *win–strong lose* trend for poverty and biodiversity (Brazil soy and to a lesser extent Mali cotton), or to a *neutral–strong lose* trend if contextual factors are unfavourable (Indonesia palm oil).
2. Cases that are less integrated into international markets, with rapid population growth, high poverty levels, low productivity and brittle ecosystems, leading to *lose–lose* trends (Nicaragua livestock, Ghana fishery) or *lose–neutral* trends (Kenya fishery, Mexico beans and maize) for poverty and biodiversity.
3. Cases with low market integration, limited access to natural and financial capital, high to moderate poverty, high population density and brittle ecosystems, leading to a *win–lose* trend (Vietnam upland and mangrove) or a *neutral–lose* trend if poor people emigrate (Ecuador), all with a tendency towards a lose–lose trend.
4. One case with low poverty levels, strong government interference and strong biodiversity protection, leading to a local *win–win* trend for poverty and biodiversity.

6.2.2 Conclusions

The relationship between biodiversity and poverty is influenced by many factors that act and counteract. The division between *market-oriented* resource use systems and *subsistence-oriented* resource use systems brings some order to the diversity of cases. Most cases are a mixture of both 'prototypes'. Whether these resource use systems lead to positive or negative trends in biodiversity and poverty change depends on cross-cutting factors. Market integration offers opportunities to generate income and reduce poverty. We call these cases *'capital driven'*. But, depending on the cross-cutting determinants, this may or may not lead to improvement in the poverty situation.

In the investigated cases the production of export crops leads to huge biodiversity losses. Strong biodiversity protection policies can help to decrease the rate of loss. Strong governance and subsidised measures are needed to compensate for lost sources of income, such as creating other jobs locally or elsewhere. This is possible if the government can raise enough money to pay for these policies and support measures, and legislation, law enforcement and institutions are well developed. This situation was found in the Costa Rica case. We call this *'policy driven'*.

Most of the subsistence-oriented cases tend towards overexploitation of natural resources, driven by high poverty levels, population densities and growth, combined with low financial and management inputs. If these processes continue in the same way, this will eventually lead to degradation of natural resources, decreasing productivity and increasing poverty: a lose–lose trend. Policy interventions have not been strong enough to turn this tide. We call these cases *'poverty driven'*.

Although they are in principle transitory and subjective in nature, we think that the three contrastive mechanisms are well-observable in practice. This typology may simplify diagnosis for intervention strategies. These insights can be used to set up future case studies and help research teams map existing situations by scoring the selected determinants.

6.3 Further reflections on the biodiversity and poverty relationship

6.3.1 Hypothetical courses of biodiversity and poverty

The cases represent snapshots of a longer process of change in biodiversity and poverty. We assume that all cases follow a limited set of basic patterns, which may differ in absolute values and in the ratio of change (angle of the slope on the graph), but in essence follow the same course. There are four hypothetical courses of combined trends in biodiversity and poverty (*Figure 6.1*).

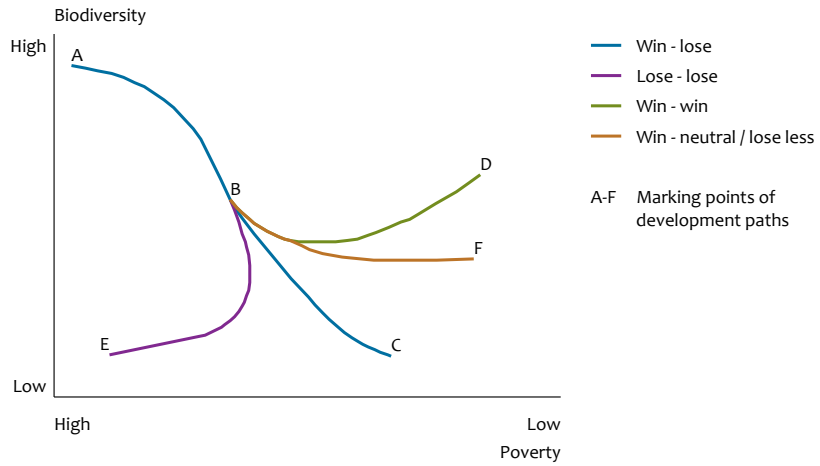
Development path A→C represents a *win–lose* relationship. People intervene in the original ecosystem, starting with gathering and hunting, then convert it into extensive and eventually into intensive cultural landscapes. Today this development may proceed rapidly and may skip one or more of these phases, as in the case of deforestation for oil palm plantations, or for extensive livestock grazing, which in turn is converted into soy fields. The original species are replaced with beneficial species, enlarging the production of goods. If human population growth is less than production growth and goods and profits are equally distributed, poverty will be reduced at the expense of biodiversity.

Development path B→D: represents the *win–win* relationship according to the green Kuznets curve. After a period following a win–lose trend (A–B), society can afford abatement measures. Biodiversity restores while the production of goods increases. If human population growth is less than production growth and the goods and profits are equally distributed, poverty will be reduced.

Development path B→E: represents a *lose–lose* relationship. After a period of win–lose development (A→B), the exploitation of ecosystems leads to the depletion of nutrients, water, energy, soil and key-species, eventually resulting in a collapse of productive capacity. Biodiversity degrades and the production of the targeted goods falls. This results in a lose–lose development if the human population is not significantly reduced and alternative employment created, even if the remaining goods and profits are equally distributed. This development is more likely in situations with a) brittle ecosystems that regenerate slowly, low fertility, low water precipitation and retention capability, high risk of depletion of production factors, b) inadequate management (no skills, no inputs) and c) overexploitation.

Development path B→F: represents a *win–neutral/lose* development or a *win more – lose less* situation. This is an intermediate path between B→C and B→D.

Hypothetical courses of biodiversity and poverty **Figure 6.1**



Hypothetical 'prototype' courses of change in biodiversity and poverty.

The above development pathways can move in the opposite direction too. The lose–lose course can turn into a win–win course: restoration (E→B). This may be actively set in motion by support from outside; importing money, skills, technology and inputs, or be initiated passively by out-migration (=abandonment of land and natural resources). The win–lose course can be reversed to become a lose–win course (C→B) by making the production system more extensive. Development courses may go back and forth or the ratio of change (slope) may alter over the course of time because of internal or contextual factors.

However, this reasoning is distorted because the case studies could not address scale and trade-off effects that exceed the boundaries of the case areas or the time period investigated. But we understand now that the relationship between poverty and biodiversity is highly scale and time dependent. Goods, money, (poor) people, technology and knowledge may cross the boundaries of the case area; consumption in one area may cause an ecological footprint elsewhere, and production today may use up tomorrow's stock. All these factors are 'hidden' in the context and conditions of the natural resource systems. If we take into account all these trade-off effects in space and time, the relationship between biodiversity and poverty may change. For example, a local win–win relationship between poverty and biodiversity may change into a win–lose relationship if we take into account the wider ecological footprint. In fact, the human pressure on biodiversity is exported to other areas. Restoration in one area is achieved by moving production and biodiversity loss to another area.

6.3.2 Step-by-step analysis of the relationship

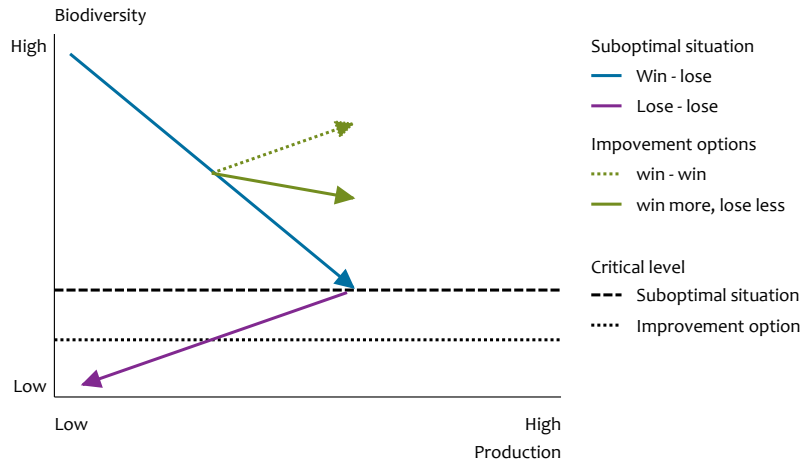
The relationship between biodiversity and poverty is analysed step by step, from biodiversity to production of goods, profits, human well-being and poverty.

Biodiversity and production

Starting from the ecosystem side, the first step in the relationship between biodiversity and poverty is the linkage between biodiversity and goods production. The extent, fertility and brittleness of the ecosystem and the actual state of biodiversity determine the opportunities available to produce goods. The actor in the resource use system determines the types and quantities of goods to be produced (*Figure 6.2*). For rural people, production increase provides the basis for income growth, improvement of human well-being and reduction of poverty. This happens at the cost of biodiversity, as it involves either an increase in the area under production or an intensification of production. Production increases at the cost of biodiversity (blue arrow in *Figure 6.2*) until pressure on the ecosystem is too high and the production capacity of the natural system is exceeded beyond a 'critical level' of exploitation. If the limits of expansion are reached, there is a risk of overexploitation and ecosystem degradation. From then on, production starts to decrease if the pressure on the ecosystem is maintained (purple arrow in *Figure 6.2*).

The qualities of the ecosystem and the characteristics of the resource use system determine the goods production per unit of biodiversity loss (area and quality), and thus the angle of the arrows in *Figure 6.2*. The brittleness of the ecosystem together with the characteristics of the resource use system determine the critical level of biodiversity at which the production process turns from a win–lose trend into a lose–lose trend. If ecosystems are brittle and production systems are badly managed, for example if fallow periods are too short and there are few external inputs and the level of technology is low, yields are low and the shift from win–lose to lose–lose will occur at an earlier stage of biodiversity loss. To maintain production levels to meet the needs of the population, more natural resources are reclaimed, if available. The period of expansion ends when all land suitable for agriculture has been reclaimed and brought into cultivation and all the fisheries have been exhausted.

Hypothetical courses of production and biodiversity **Figure 6.2**



Theoretical linkages between biodiversity and production. The green arrows show theoretical options for 'win more products–lose less biodiversity'.

The challenge is to find alternative resource use systems (*Figure 6.2*) that:

- increase production per unit biodiversity loss, for example by producing other products and using different techniques (green arrows);
- lower the critical level so that production is raised without exhausting or eroding the ecosystem, for example by changing into aquaculture instead of wild fishing (improvement option).

Production, profits, human well-being and poverty

How production leads to profits depends on markets and market integration. The cases showed that growing demand on the world market leads to a boom in exploitation with obviously high profits. Exclusion from world markets may lead to stagnation of production, decreasing profits and decreasing income if the population continues to grow. A lack of market integration, a growing population and limited and brittle ecosystems lead to increasing poverty and emigration of poor people.

How these profits help to improve human well-being and reduce poverty in the production area depends on the distribution of the profits, whether they are invested in the production area or taken out, and how many people have to share the profits. The socioeconomic systems at the local, national and global scales determine how profits are distributed. Inequality and poverty exist at every level, from the local community to world regions. Gross Domestic Product and income for the community as a whole may increase, but if these incomes are not equally distributed, poverty remains. Distribution systems may be formal or informal, direct or indirect. An unlikely combination of increased human well-being and increased poverty may occur if policies and subsidies improve basic health care and education services for people, but there is no investment in improving production systems to generate more income and specific groups of vulnerable people are excluded from the government support. Inequality grows if people who cause biodiversity loss and profit from depleting natural resources are not the ones that suffer the consequences.

Formal and informal, direct and indirect distribution systems are important determinants of poverty. The distribution system was proposed as an input indicator at the beginning of the case studies, but was eventually not chosen. The determinants 'access to natural and financial capital', 'level of poverty', 'market integration', 'employment opportunities' and 'governance' refer to inequality and distribution systems. Level of equality was one of the input indicators belonging to 'governance', but data on inequality were only available at the national scale, not at the scale of the cases.

6.3.3 Variations in the hypothetical courses

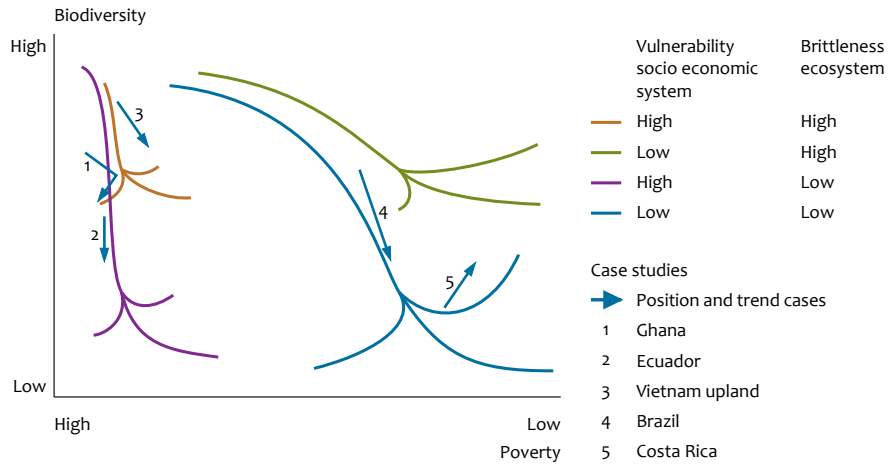
The graphs illustrating the relationship between production of goods and biodiversity (*Figure 6.2*) and the relationship between poverty and biodiversity (*Figure 6.1*) can be combined. This leads to several variants of the hypothetical courses that poverty and biodiversity may follow under different resource use systems (*Figure 6.3*). As time goes on resource use systems follow a course in their own graph of combined changes in biodiversity and poverty, as described above.

Variations in positions of the graphs in the coordinate system

For a given resource use system, the graph in the coordinate system is positioned on the vertical axis (biodiversity) according to the brittleness of the ecosystem. The graph is positioned on the horizontal axis (poverty) according to the vulnerability of the socioeconomic system. Together they influence the productivity of the resource use system, and the inequality in access to assets and share of profits.

The orange and purple graphs in *Figure 6.3* are courses followed by resource use systems that are poverty driven. The graph in the upper left corner (orange graph) represents extensive resource use systems with low or no production inputs, such as hunting, gathering and wild fishing. The combi-

Various hypothetical biodiversity - poverty pathways **Figure 6.3**



The form and position of the graphs referring to the development pathway of resource use systems is highly influenced by the brittleness of the ecosystem to degradation (vertical) and the vulnerability of the socioeconomic system (horizontal).

nation with brittle natural resources leads to a high critical level of remaining biodiversity where a win–lose course turns into a lose–lose course. Population density, population growth rate and poverty levels are high, so production means and produced goods have to be shared by an ever growing group of people. Examples among the investigated cases are fishery in Ghana and Lake Victoria, and shifting cultivation in Vietnam upland.

The graph in the bottom left corner (purple graph) represents resource use systems that also have high poverty levels. Because of extreme poverty, production inputs and management are low. Ecosystems are less brittle and the critical level where a win–lose course turns into a lose–lose course is at a lower remaining biodiversity level than in the former group. The Ecuador case is an example.

The green and blue graphs represent capital or policy driven production systems. In the bottom right corner (blue graph) are intensive and highly productive resource use systems that combine robust ecosystems with high management skills and production inputs. The remaining biodiversity in the agricultural landscape is low and poverty levels are relatively low. The capital-driven Brazil case and the policy driven Costa Rica case are examples of this type of graphs.

The green graph in the upper right corner represents resource use systems that combine brittle ecosystems and high biodiversity with relatively low poverty levels. This can exist if goods are produced that bring in high profits in a production system that has low impact on biodiversity combined with a high level of equality and low population density. There are no such examples among the cases investigated. Ecotourism in brittle natural systems like coral reefs, mangroves or tropical forest could be an example.

The four locations of the hypothetical graphs are prototypes. Most cases are somewhere in between. Every specific resource use system has its own graph.

Position of five case studies in the coordinate system

The two Ghana cases are located in the orange graph in *Figure 6.3.* They passed the turning point from a win–lose to lose–lose trend. The Vietnam upland case still has a win–lose trend, but may be close to the turning point if the overexploitation of the forest is considered and intensification of agricultural production does not take place.

The Ecuador case follows the purple graph in *Figure 6.3*, poverty is stable but at the cost of biodiversity loss. Expansion of production continues but poor people emigrate too. The production system stands at the threshold of a turning point towards a lose–lose process.

The capital driven Brazilian case is following a win-lose course in the blue graph. The policy-driven Costa Rica case is moving upwards from a low level of remaining biodiversity, following a course of restoration in the same blue graph. Strong government interference turned the course into a win–win.

Resource use systems develop over time, as do poverty–biodiversity relationships. This may happen gradually, but cases exist in which a complete new resource use system displaces existing resource use systems. For example, the production of a commodity for international markets may be introduced into an area previously only exploited for subsistence agriculture. This causes a system shift, with a new graph for the biodiversity–poverty relationship. At the start of the production of the new commodity, biodiversity and poverty levels have certain values resulting from the former resource use systems in the area. Therefore, the new resource use system may not necessarily start at the upper left corner of the graph.

Other mechanisms

Other mechanisms also exist, such as changes caused by natural disasters, war and conflicts, market collapse and invasive species. These can be seen as contextual factors because they are beyond the influence of the actor in the resource use

system. They have strong impacts on the resource use system in a short time period.

Market collapse can be understood as the inverse situation of market integration and results in poverty and bankruptcies among farmers and resource users. War and conflict can be seen as extremely unfavourable scores on the scale of the governance factor affecting social, economic and ecological capital. The impact of past war and conflict was mentioned as a cause of the poverty-driven mechanism in some cases. Conflicts exist or existed not only in the case study areas of Vietnam and Nicaragua, but also in southern Mexico (the Zapatista uprising), in Ghana (between the canoe fishery sector and the industrial fleet), in Mali (between sedentary farmers and nomad pastoralists), and in the mangrove area in Vietnam (on access to the 'commons' by the poor). Policies can be effective in countering the negative impacts of conflicts on people and the environment. Pro-poor policies played a part in ending the conflict with the Zapatista movement in southern Mexico.

An example of poverty and biodiversity loss due to environmental shocks and stresses was found in the mangrove case in Vietnam. Cyclones and tropical storms damaged infrastructure and the means of production, causing a drop in economic growth from 8% to 3% locally in 2005, and also damaged nature reserves. Environmental shocks have a greater negative impact on production and livelihoods if the ecosystem is brittle, if production means are destroyed and if people do not have the capacity to adapt to these disasters or restore the damage. Environmental disasters are linked to the brittleness of ecosystems, actor type, level of poverty and the intensity and extent of the natural resource use.

Invasive species can hamper the restoration of original biodiversity and suppress production. A special case is the introduction of Nile Perch into Victoria Lake (Kenya case). At first, this invasive species was a damaging predator of the traditional fish stocks, then was exported in large numbers and became the main source of income, and was finally overexploited.

More research is needed on the environmental shocks and stresses and the war and conflict mechanisms, especially in view of the anticipated effects of climate change on goods production, which are expected to lead to a scarcity of goods and resources.

6.3.4 Can a green Kuznets curve exist?

The key question is whether a resource use system exists in which both production and biodiversity increase: a win–win trend. We did not find a case with a win–win trend for poverty and biodiversity when trade-off effects are taken into account. This raises the question of whether a green Kuznets curve exists. We have reasons to assume that the answer is no, in contrast to the grey (environmental) Kuznets curve. Environmental quality can be improved by taking technical measures, whereas technical measures hardly reduce the impact on biodiversity of the production of basic commodities such as food, fibre, fish and water. As was shown in Chapter 3, human development is characterised by the replacement of non-beneficial species with beneficial species (homogenisation and parcellation). In essence, humans are in direct competition with their fellow creatures for space, energy, minerals, food and water. As far as we know, this fundamental competition cannot be removed by technical solutions. Only when the efficiency of resource use systems is suboptimal, so that resources are spoiled or wasted, is it theoretically possible to change the development pathway to create win–win trends for biodiversity and goods production by adopting a more efficient resource use system that uses up fewer natural resources while increasing production. If goods and profits are equally distributed, this can lead to win–win trends for biodiversity and poverty too.

6.4 Recommendations for further research

This study was exploratory in nature. We found that a set of 16 determinants, supplemented with an indicator on distribution systems, get a long way in describing the main factors that determine the changes in biodiversity and poverty and the relationship between them. We also defined three prototype mechanisms. More studies on these determinants and mechanisms in other cases will be necessary to confirm these findings.

If our findings are confirmed, the indicators associated with the sets of determinants identified in this study could be used in a monitoring system because together they explain the mechanisms behind the outcomes.

The quantitative relationships between biodiversity, production of goods and ecosystem services are not yet understood. How do they depend on ecosystem extent, fertility, brittleness and condition, and on the resource use system? A quantitative investigation is needed on how people depend on these goods and services for their livelihoods and well-being.

Little is known about the brittleness of ecosystems and their vulnerability to exploitation by man. What are the critical levels of biodiversity in different natural systems beyond which the system is overexploited? Can the brittleness of ecosystems and the properties of resource use systems that put pressure on the ecosystems be defined by indicators, quantified and mapped?

What are the effects of natural resource management and policy interventions in different circumstances? Can these circumstances be typified by the determinants and mechanisms found, and do they help to predict the effectiveness of policy interventions?

The case studies focused on rural areas and we did not investigate the relationship between these rural areas and urban areas. These relationships are very important for the development of rural areas, for example through the transfer of people, money, goods and knowledge. Developments in rural areas can only be fully understood if urban–rural relationships are taken into account.

Annex 1 Scores of input indicators and outcome indicators of 11 case studies

Scores of input indicators and outcome indicators of 11 case studies **Table A1.1**

		Terrestrial systems									Aquatic systems	
Input indicators	**Legend**	**Brazil**	**Costa Rica**	**Ecua-dor**	**Indo-nesia**	**Mali**	**Mexico**	**Nica-ragua**	**Viet-nam man-grove**	**Vietnam upland**	**Marine Ghana**	**Fresh water Kenya**
1.1.1 Absolute population density (inhabitants per km2)	1 = high	5	3	2	2	3	4	4	2	2	1	1
1.1.2 Rate of population change (% per year)	1 = high rate	3	5	3	3	2	1	1	2	2	2	1
1.2.1 Level of corruption	1 = bad	3	4	1	1	1	3	2	2	1	3	1
1.2.2 Level of equality	1 = bad	2	3	3	4	3	2	1	2	4	4	1
1.2.3 Level of voice and accountability	1 = bad	4	4	3	3	4	4	2	3	2	4	3
1.2.4 Level of rule of law in the focus area	1 = bad	3	4	2	2	3	3	2	3	3	3	4
1.2.5 Level of political stability / violence	1 = bad	3	5	2	2	3	3	2	4	4	4	4
1.2.6 Level of government effectiveness	1 = bad	4	4	2	3	3	4	3	3	3	4	2
1.3.1 Policies stimulating expansion of commodities	1 = no expand	5	3	2	5	4	2	3	4	2	4	5
1.3.2 Policies stimulating intensification	1 = no intensification	4	4	3	2	4	4	3	5	4	4	3
1.3.3 Policies stimulating diversification	1 = no diversification	2	5	1	2	2	2	2	3	3	1	2
1.3.4 Policies stimulating added value activities and/or non-farm	1 = no non-farm	4	3	2	2	1	1	2	1	3	2	3
1.3.5 Policies stimulating protection of natural ecosystems	5 = many	3	5	3	2	3	3	3	4	5	2	2
1.4.1 Level of integration in national or global markets	1 = low level	5	4	2	5	4	3	3	3	2	3	3
1.4.2 Growth potentials for commodities produced	1 = low potential	5	4	2	5	3	2	3	5	3	2	3
1.4.3 Long term profitability of commodity/ies produced	1 = very low	5	2	2	5	2	2	3	4	1	4	3
1.4.4 Value added by primary and secondary processing	1 = low	3	3	2	2	2	2	3	2	1	3	3
1.4.5 Power concentration in the market chain	1 = very low	5	4	2	5	4	4	3	3	1	3	4
2.1.1 Proportion of ecosystems with original biodiversity	1 = low	5	1	3	4	1	3	4	2	3	5	4
2.1.2 Susceptibility of ecosystems to environmental degradation	1 = high	4	3	2	2	3	3	2	1	1	2	2
2.1.3 Rate of recent land-use change in focus area	1 = high	2	5	3	1	3	4	1	4	2	4	3
2.2.1 Level of poverty in focus area	1 = high	3	5	1	3	1	3	2	3	1	1	1
2.2.2 Level of human development in focus area	1 = low	3	5	2	3	2	5	2	3	2	1	2
2.2.3 Incidence of hunger in the focus area	1 = high	3	5	2	3	3	4	2	4	2	2	3
2.2.4 Employment opportunities in and around the focus area	1 = low	4	3	2	2	2	3	2	2	1	2	2
3.1.1 Dominant actor type in terms of production volume and area	1 = easy access	4	3	1	4	2	1	2	1	1	1	2

		Terrestrial systems									Aquatic systems	
Input indicators	**Legend**	**Brazil**	**Costa Rica**	**Ecua-dor**	**Indo-nesia**	**Mali**	**Mexico**	**Nica-ragua**	**Viet-nam man-grove**	**Vietnam upland**	**Marine Ghana**	**Fresh water Kenya**
3.2.1 Access to natural capital bij dominant actor type	1 = poor access	4	2	2	4	3	2	3	1	1	3	4
3.2.2 Access to financial capital by dominant actor type	1 = poor access	5	4	2	4	4	3	2	1	2	3	3
3.2.3 Dependence on natural versus capital resources by dominant actor type	1 = NR dependent	4	3	3	4	3	3	3	1	2	1	1
3.3.1 Labour productivity by dominant actor type	1 = low level	5	4	2	4	3	1	1	1	2	1	3
3.3.2 Diversity of products by dominant actor type	1 = high	5	4	2	5	3	3	4	1	1	4	3
3.3.4 Productivity per unit of land or resource by dominant actor type	1 = low	5	4	2	4	3	2	2	2	2	4	2
3.3.5 Level of capacities and skills by dominant actor type	1 = low	5	4	2	4	3	2	2	1	2	1	2

		Terrestrial systems									Aquatic systems	
4. Outcome indicators	Legend	Brazil	Costa Rica	Ecua-dor	Indo-nesia	Mali	Mexico	Nicara-gua	Viet-nam man-grove	Vietnam upland	Marine Ghana	Fresh water Kenya
4.1 Biodiversity	-2 = strong decline	-2	1	-1	-2	-2	0	-2	-1	-1	-1	0
4.2 Goods (production)	+2 = strong increase	2	-1	1	2	2	0	1	1	0	0	-1
4.3 Human well-being		1	1	0	0	1	2	0	1	1	-1	-1
4.4 Poverty	Inverse: -2 = strong increase	1	1	0	0	1	-1	-1	1	1	-1	-1

+2 = strong decline

Annex 2 Legend of input indicators

1. Context

1.1 Demographic factors

INPUT INDICATOR 1.1.1 Absolute population density (in the focus area) **Table A2.1**

Score	Description	Observations
1	Very high population density: more than 100 inhabitants per km² (*Unfavourable*)	
2	High population density: 50-100 inhabitants per km²	
3	Average population density: 25-50 inhabitants per km²	
4	Low population density: 10-25 inhabitants per km²	
5	Very low population density: less than 10 inhabitants per km² (*Favourable*)	

INPUT INDICATOR 1.1.1 Absolute population density (in the focus area)
Rationale: Absolute population density is an indication of pressure on natural resources, but on the other hand low population density may reflect a low level of organisation and may allow easy access of natural resources by outsiders and little control on their exploitation process.

INPUT INDICATOR 1.1.2 Rate of population change **Table A2.2**

Score	Description	Observations
1	Very high rate of population increase: 3% or more (*Unfavourable*)	
2	High rate of population increase: 2-3%	
3	Moderate rate of population increase: 1-2%	
4	Low rate of population increase: 0-1%	
5	Rate of population decline (*Favourable*)	

INPUT INDICATOR 1.1.2 Rate of population change
Rationale: A high rate of population change (high birth rate or immigration) implies a risk for both natural resources and institutions responsible for natural resources management. It can also lead to resource scarcity, social and ethnic tensions and conflicts.

1.2 Governance factors

NB. In most cases the index on the following 6 indicators will reflect available data from national level, as more detailed information from the focus area is generally not available. However, where more specific data from the focus area are available, these have been used.

INPUT INDICATOR 1.2.1 Level of corruption

Table A2.3

Score	Description	Observations
1	Level of corruption lower than 2.5, as based on the score of the country on the Transparency International corruption perceptions index. (*Unfavourable*)	
2	Level of corruption between 2.5 and 3.0, as based on the score of the country on the Transparency International corruption perceptions index.	
3	Level of corruption between 3.0 and 4.0, as based on the score of the country on the Transparency International corruption perceptions index.	
4	Level of corruption between 4.0 and 5.0, as based on the score of the country on the Transparency International corruption perceptions index.	
5	Level of corruption higher than 5.0, as based on the score of the country on the Transparency International corruption perceptions index. (*Favourable*)	

INPUT INDICATOR 1.2.1 Level of corruption
Rationale: High level of corruption implies greater chance for illegal exploitation and resource-use practices with negative impacts on the environment and human well-being. Level of corruption in the focus area may be based on national transparency international corruption index.
See: http://www.transparency.org/policy_research/surveys_indices/cpi/2006

INPUT INDICATOR 1.2.2 Level of inequality

Table A2.4

Score	Description	Observations
1	Very high level of inequality / Gini index higher than 60, possibly based on national level Gini index. (*Unfavourable*)	
2	High level of inequality / Gini index between 50 and 60, possibly based on national level Gini index.	
3	Moderate level of inequality / Gini index between 40 and 50, possibly based on national level Gini index.	
4	Low level of inequality / Gini index between 30 and 40, possibly based on national level Gini index.	
5	Very low level of inequality / Gini index lower than 30, possibly based on national level Gini index. (*Favourable*)	

INPUT INDICATOR 1.2.2 Level of inequality
Rationale: High level of inequality implies a high Gini index (difference between richest and poorest 20% of society) and signifies high probability of social groups being left out of the development process. Level of equality in the focus area may be based on national Gini index if local values are not available.
See: http://hdr.undp.org/reports/global/2003/indicator/indic_126_2_1.html

INPUT INDICATOR 1.2.3 Level of voice and accountability

Table A2.5

Score	Description	Observations
1	Data not available (*Unfavourable*)	
2	Ranking of voice and accountability index in lowest 25% percentile, based on national value.	
3	Ranking of voice and accountability index in 25%-50% percentile, based on national value.	
4	Ranking of voice and accountability index in 50%-75% percentile, based on national value.	
5	Ranking of voice and accountability index in 75%-100% percentile, based on national value. (*Favourable*)	

INPUT INDICATOR 1.2.3 Level of voice and accountability
Rationale: Low level of voice and accountability signifies low level of participation and thus high probability of illegal exploitation or practices that do not benefit the people.
See: http://info.worldbank.org/governance/kkz2005/

INPUT INDICATOR 1.2.4 Level of rule of law

Table A2.6

Score	Description	Observations
1	Data not available (*Unfavourable*)	
2	Ranking of rule of law index in lowest 25% percentile, based on national value.	
3	Ranking of rule of law index in 25%-50% percentile, based on national value.	
4	Ranking of rule of law index in 50%-75% percentile, based on national value.	
5	Ranking of rule of law index in 75%-100% percentile, based on national value. (*Favourable*)	

INPUT INDICATOR 1.2.4 Level of rule of law
Rationale: Low level of rule of law signifies poor law enforcement including environmental and social legislation.
See: http://info.worldbank.org/governance/kkz2005/

INPUT INDICATOR 1.2.5 Level of political stability / violence

Table A2.7

Score	Description	Observations
1	Data not available (*Unfavourable*)	
2	Ranking of political stability index in lowest 25% percentile, based on national value.	
3	Ranking of political stability index in 25%-50% percentile, based on national value.	
4	Ranking of political stability index in 50%-75% percentile, based on national value.	
5	Ranking of political stability index in 75%-100% percentile, based on national value. (*Favourable*)	

NPUT INDICATOR 1.2.5 Level of political stability / violence
Rationale: Low level of political stability and incidence of violence signifies high probability of illegal exploitation or practices and social unrest.
See: http://info.worldbank.org/governance/kkz2005/

INPUT INDICATOR 1.2.6 Level of government effectiveness

Table A2.8

Score	Description	Observations
1	Data not available (*Unfavourable*)	
2	Ranking of government effectiveness index in lowest 25% percentile, based on national value.	
3	Ranking of government effectiveness index in 25%-50% percentile, based on national value.	
4	Ranking of government effectiveness index in 50%-75% percentile, based on national value.	
5	Ranking of government effectiveness index in 75%-100% percentile, based on national value. (*Favourable*)	

INPUT INDICATOR 1.2.6 Level of government effectiveness
Rationale: Low level of government effectiveness signifies poor government services in the focus area, thus no compensation measures or social improvement programs.
See: http://info.worldbank.org/governance/kkz2005/

1.3 Policy factors (pro-poor and pro-biodiversity)

INPUT INDICATOR 1.3.1 Policies stimulating volume and expansion of main commodities in the focus area

Table A2.9

Score	Description	Observations
1	Existing policies strongly discourage expansion of main commodities produced in the case focus area *(Unfavourable)*	
2	Existing policies discourage expansion of main commodities produced in the case focus area	
3	Existing policies do stimulate nor discourage expansion of main commodities produced in the case focus area	
4	Existing policies stimulate expansion of main commodities produced in the case focus area	
5	Existing policies strongly stimulate expansion of main commodities produced in the case focus area (*Favourable*)	

INPUT INDICATOR 1.3.1 Policies stimulating volume and expansion of main commodities in the focus area
Rationale: Policies with high a level of stimulating volume and expansion push economic growth and poverty alleviation. However, exaggerations may trigger unsustainable growth and inequality.

INPUT INDICATOR 1.3.2 Policies stimulating intensification of production systems in the focus area

Table A2.10

Score	Description	Observations
1	Existing policies strongly discourage intensification *(Unfavourable)*	
2	Existing policies discourage intensification	
3	Existing policies do not stimulate nor discourage intensification	
4	Existing policies stimulate intensification	
5	Existing policies strongly stimulate intensification (*Favourable*)	

INPUT INDICATOR 1.3.2 Policies stimulating intensification of production systems in the focus area
Rationale: Policies should stimulate intensification of production systems (i.e. yields per hectare) to make efficient use of available natural resources and space available, and thus also reduce the need for further expansion.

INPUT INDICATOR 1.3.3 Policies stimulating diversification of production systems in the focus area

Table A2.11

Score	Description	Observations
1	Existing policies strongly discourage diversification *(Unfavourable)*	
2	Existing policies discourage diversification	
3	Existing policies do not stimulate nor discourage diversification	
4	Existing policies stimulate diversification	
5	Existing policies strongly stimulate diversification *(Favourable)*	

INPUT INDICATOR 1.3.3 Policies stimulating diversification of production systems in the focus area
Rationale: Policies that stimulate diversification of production systems will reduce dependency on single markets for commodities, and thus be beneficial to poverty reduction.

INPUT INDICATOR 1.3.4 Policies stimulating added value and off-farm employment

Table A2.12

Score	Description	Observations
1	Existing policies strongly discourage added value activities and off-farm employment *(Unfavourable)*	
2	Existing policies discourage added value activities and off-farm employment	
3	Existing policies do not stimulate nor discourage added value activities and off-farm employment	
4	Existing policies stimulate added value activities and off-farm employment	
5	Existing policies strongly stimulate added value activities and off-farm employment *(Favourable)*	

INPUT INDICATOR 1.3.4 Policies stimulating added value and off-farm employment
Rationale: Policies that stimulate added value and off-farm activities will reduce the pressure on available natural resources and also generate employment and create incomes for different social groups.

1.3.5 Policies stimulating protection of natural ecosystems in the focus area

Table A2.13

Score	Description	Observations
1	No policies stimulating protection of natural ecosystems and restoration of degraded ecosystems (*Unfavourable*)	
2	Few policies stimulating protection of natural ecosystems and restoration of degraded ecosystems	
3	Some policies stimulating protection of natural ecosystems and restoration of degraded ecosystems	
4	Several policies stimulating protection of natural ecosystems and restoration of degraded ecosystems	
5	Many policies stimulating protection of natural ecosystems and restoration of degraded ecosystems, which means restricted assess to natural resources for the poor. (*Favourable*)	

1.3.5 Policies stimulating protection of natural ecosystems in the focus area
Rationale: Low level of protection of natural ecosystems and lacking restoration of degraded ecosystems (e.g. reforestation, erosion control, mangrove rehabilitation and payment for environmental services) enables and stimulates exploitation of remaining natural ecosystems. This is negative for biodiversity.

1.4 Market factors

INPUT INDICATOR 1.4.1 Level of integration in / dependency of focus area economy on national or global markets

Table A2.14

Score	Description	Observations
1	Low level of integration of focus area production systems in global & national markets (*Unfavourable*)	
2	Low level of integration of focus area production systems in global markets, moderate in national markets	
3	Low level of integration of focus area production systems in global markets, high in national markets	
4	Moderate level of integration of focus area production systems in global markets	
5	High level of integration of focus area production systems in global markets (*Favourable*)	

INPUT INDICATOR 1.4.1 Level of integration in / dependency of focus area economy on national or global markets
Rationale: High level of integration in / dependency of focus area economy on external (national, global) markets creates opportunities for economic growth. However, it also requires measures to avoid unsustainable growth and inequality.

INPUT INDICATOR 1.4.2 Growth potentials for the main commodities being produced in the focus area

Table A2.15

Score	Description	Observations
1	No growth potentials for commody/ies produced in focus area (e.g. based on national / global demand). *(Unfavourable)*	
2	Very limited growth potentials for commody/ies produced in focus area (e.g. based on national / global demand).	
3	Moderate growth potentials for commody/ies produced in focus area (e.g. based on national / global demand).	
4	High growth potentials for commody/ies produced in focus area (e.g. based on national / global demand).	
5	Very high growth potentials for commody/ies produced in focus area (e.g. based on national / global demand). *(Favourable)*	

INPUT INDICATOR 1.4.2 Growth potentials for the main commodities being produced in the focus area
Rationale: High growth potentials for the commodity/ies being produced in the focus area creates opportunities for commodity development and economic growth.

INPUT INDICATOR 1.4.3 Long term profitability of main commodity/ies produced in focus area

Table A2.16

Score	Description	Observations
1	Very low long-term profitability, e.g. by low and unstable prices of commodities produced in focus area, *(Unfavourable)*	
2	Low long-term profitability, e.g. by relatively low and fluctuating prices of commodities produced in focus area	
3	Average long-term profitability, e.g. by average price conditions of commodities produced in focus area	
4	High long-term profitability, e.g. by relatively high but fluctuating prices of commodities produced in focus area	
5	Very high long-term profitability, e.g. by high and stable prices of commodities produced in focus area *(Favourable)*	

INPUT INDICATOR 1.4.3 Long term profitability of main commodity/ies produced in focus area
Rationale: Absence of long term profitability of commodity/ies produced in focus area signifies risks for profitability, bankruptcy among enterprises, unsustainable growth and strongly fluctuating prices for commodities.

INPUT INDICATOR 1.4.4 Value added by primary and secondary processing in the focus area

Table A2.17

Score	Description	Observations
1	No value added activities in the focus area, or nearby, to transform primary products into secondary etc. products with value added. *(Unfavourable)*	
2	Very few value added activities in the focus area, or nearby, to transform primary products into secondary etc. products with value added.	
3	Some value added activities in the focus area, or nearby, to transform primary products into secondary etc. products with value added.	
4	Much value added activities in the focus area, or nearby, to transform primary products into secondary etc. products with value added.	
5	Numerous value added activities in the focus area, or nearby, to transform primary products into secondary etc. products with value added. *(Favourable)*	

INPUT INDICATOR 1.4.4 Value added by primary and secondary processing in the focus area (of main commodity/ies produced in the focus area)
Rationale: No value added by primary and secondary processing implies a loss of opportunities for employment and income generation.

INPUT INDICATOR 1.4.5 Power concentration in the market chain of main commodity/ies produced in focus area

Table A2.18

Score	Description	Observations
1	Very low level of power concentration in one or more stages of the production chain and/or low level of vertical integration *(Unfavourable)*	
2	Low level of power concentration in one or more stages of the production chain and/or low level of vertical integration	
3	Limited level of power concentration in one or more stages of the production chain and/or limited level of vertical integration	
4	High level of power concentration in one or more stages of the production chain (few global companies involved) and/or high level of vertical integration	
5	Very high level of power concentration in one or more stages of the production chain (very few global companies involved) and/or high level of vertical integration *(Favourable)*	

INPUT INDICATOR 1.4.5 Power concentration in the market chain of main commodity/ies produced in focus area
Rationale: High level of power concentration and vertical integration in the market chain of the main commodity produced in the focus area signifies the possibility for rapid adaptation capacity to changes (negative or positive) as only few actors need to take decisions.

2. Resources

2.1 Natural system

INPUT INDICATOR 2.1.1 Proportion of remaining natural ecosystems with original biodiversity in focus area Table A2.19

Score	Description	Observations
1	Very low (<5%) proportion of area located in Intact Forest Landscapes, High Conservation Value Forests, High Conservation Value Areas, or other standards. *(Unfavourable)*	
2	Low (5-10%) proportion of area located in Intact Forest Landscapes, High Conservation Value Forests, High Conservation Value Areas, or other standards.	
3	Moderate (10-25%) proportion of area located in Intact Forest Landscapes, High Conservation Value Forests, High Conservation Value Areas, or other standards.	
4	High (25-50%) proportion of area located in Intact Forest Landscapes, High Conservation Value Forests, High Conservation Value Areas, or other standards.	
5	Very high (>50%) proportion of area located in Intact Forest Landscapes, High Conservation Value Forests, High Conservation Value Areas, or other standards. *(Favourable)*	

INPUT INDICATOR 2.1.1 Proportion of remaining natural ecosystems with original biodiversity in focus area
Rationale: High proportion of remaining natural ecosystems with original biodiversity levels implies that opportunities still exits for further exploitation of potential ecosystem goods and services. However, exploitation can have high impacts on biodiversity. Different measures can be used.
On intact forests: www.intactforests.org/
On high conservation forests: www.proforest.net/publications/hiconvf
On high conservation value areas: http://www.hcvnetwork.org

INPUT INDICATOR 2.1.2 Susceptibility to degradation of natural resources by production systems in focus area Table A2.20

Score	Description	Observations
1	High predominance of fragile ecosystems, susceptible to irreversible degradation. *(Unfavourable)*	
2	Predominance of fragile ecosystems, susceptible to irreversible degradation.	
3	Presence of fragile ecosystems, susceptible to irreversible degradation.	
4	Very few fragile ecosystems, susceptible to irreversible degradation.	
5	No fragile ecosystems, susceptible to irreversible degradation. *(Favourable)*	

INPUT INDICATOR 2.1.2 Susceptibility to degradation of natural resources by production systems in focus area
Rationale: Some natural resources are more susceptible to degradation if exploited than others, resulting into decreasing productivity and income. Degradation can occur in the form of soil erosion, water balance disturbance, climate change etc. because of overexploitation above the carrying capacity.

INPUT INDICATOR 2.1.3 Rate of recent land-use change in focus area Table A2.21

Score	Description	Observations
1	Very high rate of decline of natural ecosystems (>10% in recent 5 years) *(Unfavourable)*	
2	High rate of decline of natural ecosystems (5-10% in recent 5 years)	
3	Moderate rate of decline of natural ecosystems (2-5% in recent 5 years)	
4	Low rate of decline of natural ecosystems (<2% in recent 5 years)	
5	Increase of natural ecosystems by setting aside areas or restoration of degraded areas *(Favourable)*	

INPUT INDICATOR 2.1.3 Rate of recent land-use change in focus area
Rationale: High rate of decline of natural ecosystems implies a risk for degradation. Other ecosystem services than the targeted one may decline and become a risk for sustainable economic growth in the area.

2.2 Socioeconomic system

INPUT INDICATOR 2.2.1 Level of poverty in focus area Table A2.22

Score	Description	Observations
1	Very high rate of poverty (indicators: very high HPI > 50, very high proportion population with income below 1$: > 50%). *(Unfavourable)*	
2	High rate of poverty (indicators: high HPI 30-50, high proportion population with income below 1$: 30-50%).	
3	Moderate rate of poverty (indicators: HPI 10-30, proportion population with income below 1$: 10-30%, …).	
4	Low rate of poverty (indicators: low HPI 5-10, proportion population with income below 1$: 5-10%).	
5	Very low rate of poverty (indicators: HPI less than 5, proportion population with income below 1$: less than 5%). *(Favourable)*	

INPUT INDICATOR 2.2.1 Level of poverty in focus area (vulnerability to poverty)
Rationale: High level of poverty implies a low value of social capital: poor defense mechanisms against outsiders, low access to credit and technology and low chances for more profitable and sustainable practices will be adopted. This variable shows the level of vulnerability of the rural society to poverty at the start of the period under study.
The poverty rate in the focus area may be based on national statistics if specific data are not available.
See for countries: http://hdr.undp.org/hdr2006/statistics/indices/default.cfm.

INPUT INDICATOR 2.2.2 Level of human development in focus area

Table A2.23

Score	Description	Observations
1	Very low level of human development, HDI lower than 0.43 *(Unfavourable)*	
2	Low level of human development, HDI between 0.43 and 0.50	
3	Moderate level of human development, HDI between 0.50 and 0.60	
4	High level of human development, HDI between 0.60 and 0.70	
5	Very high level of human development, HDI higher than 0.70 *(Favourable)*	

INPUT INDICATOR 2.2.2 Level of human development in focus area
Rationale: Low level of human development (including life expectancy, literacy, education and income) implies a low value of social capital: poor defense mechanisms against outsiders and low likelihood that more sustainable practices will be adopted.
The HDI in the focus area may be based on national statistics if specific data are not available.
See for countries: http://en.wikipedia.org/wiki/List_of_countries_by_Human_Development_Index.

INPUT INDICATOR 2.2.3 Incidence of hunger in the focus area

Table A2.24

Score	Description	Observations
1	Very high proportion of malnutrition (severe and moderate: > 40%) *(Unfavourable)*	
2	High proportion of malnutrition (severe and moderate: 30-40%)	
3	Moderate proportion of malnutrition (severe and moderate: 20-30%)	
4	Low proportion of malnutrition (severe and moderate: 10-20%)	
5	Very low proportion of malnutrition (severe and moderate < 10%) *(Favourable)*	

INPUT INDICATOR 2.2.3 Incidence of hunger in the focus area
Rationale: High incidence of malnutrition will worsen conditions for education and training, labor productivity, sustainable resource use and efficient production systems.
The incidence of hunger may be based on national statistics if specific data are not available.
See: http://childinfo.org/areas/malnutrition/underweight.php

INPUT INDICATOR 2.2.4 Employment opportunities in and around the focus area

Table A2.25

Score	Description	Observations
1	Very low level of employment opportunities, e.g. based on urbanization rate *(Unfavourable)*	
2	Low level of employment opportunities, e.g. based on urbanization rate	
3	Moderate level of employment opportunities, e.g. based on urbanization rate	
4	High level of employment opportunities, e.g. based on urbanization rate	
5	Very high level of employment opportunities, e.g. based on urbanization rate *(Favourable)*	

INPUT INDICATOR 2.2.4 Employment opportunities in and around the focus area
Rationale: High level of employment opportunities in and around the focus area, including temporal and permanent migration, will stimulate natural resource users exit from agriculture. Pressure on the environment may decrease, but economic development and innovation may increase. Alternative jobs can be the escape for poor landless and collapsed subsistence-based production.

3. Resource-use systems

3.1 Actor types

Rationale: We distinguished 4 actor types: (1) subsistence, (2) semi-commercial, (3) commercial and (4) corporate. It is not yet clear whether any of these types is more or less associated with unsustainable resource-use. Predominance is here interpreted in terms of production volume per (household) economic unit and attitude towards market integration.

The following classification of actor types is proposed:

1. *subsistence* resource users: their primary goal is to produce sufficient food for their family. In addition they may also produce for the market. Part of their income is earned outside the primary production activity. They often lack access to inputs and are the most vulnerable group. Part of this group may stop and migrate to other areas to look for employment; the more successful members may become semi-commercial resource users.
2. *semi-commercial* resource users: they produce (part of) their own food requirement but produce also for the market. They have a good access to inputs. These users may also migrate, but may also become a subsistence resource user or a commercial resource user.
3. *commercial* resource users: they produce basically for the market and apply recommended levels of external inputs such as synthetic fertilizers and pesticides. The owner works on the production unit. Also these resource users may migrate or become semi-commercial resource user.
4. *corporate* resource users: the production units are often parts of very large and diversified corporations.

INPUT INDICATOR 3.1.1 Dominant actor types

Table A2.26

Score	Description	Observations
1	Predominance of subsistence actor type number 1	
2	Predominance of semi-commercial actor type number 2	
3	Predominance of commercial actor type number 3	
4	Predominance of corporate actor type number 4	
5	Mix of all actor types, no clear dominance.	

3.2 Access to inputs

Case studies were requested to complete information for all actor types in de focus area (in different columns) but for the comparison matrix we only used the information for the dominant actor type as this is characteristic for the production system at the case study level.

INPUT INDICATOR 3.2.1 Access to natural capital by dominant actor type

Table A2.27

Score	Description	1	2	3	4
1	Very restricted access to natural capital by dominant actor types (very high cost of land, very strict legislation, very strict ownership). *(Unfavourable)*				
2	Restricted access to natural capital by dominant actor types (high cost of land, strict legislation, strict ownership).				
3	Moderate access to natural capital by dominant actor types (moderate cost of land, normal legislation, clear ownership).				
4	Easy access to natural capital by dominant actor types (low cost of land, easy legislation, no strict ownership, easy bribery).				
5	Very easy access to natural capital by dominant actor type (low cost of land, easy legislation, no strict ownership, no bribe costs required). *(Favourable)*				

INPUT INDICATOR 3.2.1 Access to natural capital by dominant actor type
Rationale: Easy access to natural capital may be one factor leading to rapid expansion, increased production and economic growth.

INPUT INDICATOR 3.2.2 Access to financial capital by dominant actor type

Table A2.28

Score	Description	1	2	3	4
1	Very poor access to financial capital by dominant actor type (very high interest rate, no government subsidies, no private sector investments, no stimulating policies). *(Unfavourable)*				
2	Poor access to financial capital by dominant actor type (high interest rate, no government subsidies, few private sector investments, no stimulating policies).				
3	Moderate access to financial capital by dominant actor types (average interest rate, some government subsidies, some private sector investments).				
4	Easy access to financial capital by dominant actor types (low interest rate, government subsidies, private sector investments, stimulating policies).				
5	Very easy access to financial capital by dominant actor types (very low interest rate, high government subsidies, large private sector investments, stimulating policies). *(Favourable)*				

INPUT INDICATOR 3.2.2 Access to financial capital by dominant actor type
Rationale: Easy access to financial capital allows for high investments for intensification and or rapid change or expansion of exploitation systems.

INPUT INDICATOR 3.2.3 Natural versus financial capital inputs by dominant actor type

Table .29

Score	Description	1	2	3	4
1	Resource-use systems for their proper functioning highly depend upon ecosystem services, there are very few external inputs (energy, materials, capital) *(Unfavourable)*				
2	Resource-use systems for their proper functioning highly depend upon ecosystem services, there are few external inputs (energy, materials, capital)				
3	Resource-use systems for their proper functioning depend upon both ecosystem services and external inputs (energy, materials, capital)				
4	Resource-use systems for their proper functioning highly depend upon external inputs (energy, materials, capital), and less so on ecosystem services				
5	Resource-use systems for their proper functioning highly depend upon external inputs (energy, materials, capital), and very little on ecosystem services *(Favourable)*				

INPUT INDICATOR 3.2.3 Natural versus financial capital inputs by dominant actor type
Rationale: Resource-use systems vary as regards their dependence on ecosystem services or financial management inputs, for proper functioning, and thus their pressure on natural resources.

3.3 Management of production process

INPUT INDICATOR 3.3.1 Labor productivity by the dominant actor type

Table .30

Score	Description	1	2	3	4
1	Very low level of labor productivity, very low level of mechanization *(Unfavourable)*				
2	Low level of labor productivity, low level of mechanization				
3	Moderate level of labor productivity, some level of mechanization				
4	High level of labor productivity, high level of mechanization				
5	Very high level of labor productivity, high level of mechanization *(Favourable)*				

INPUT INDICATOR 3.3.1 Labor productivity by the dominant actor type
Rationale: Low labor productivity will hamper innovation and other economic developments and restrict farmers to expand the area cultivated.

INPUT INDICATOR 3.3.2 Diversity of commodities by the dominant actor type

Table .31

Score	Description	1	2	3	4
1	Very high diversity of products, high diversity of products *(Unfavourable)*				
2	High diversity of products, diversity of products				
3	Some diversity of products, but clear main crop				
4	Low diversity of products, monocultures with very few other products				
5	Monoculture *(Favourable)*				

INPUT INDICATOR 3.3.2 Diversity of commodities by the dominant actor type
Rationale: Low diversity of products makes the system more vulnerable, especially for subsistence farmers, but productivity may increase and specialization of production is required to insert successfully into (inter)national markets.

INPUT INDICATOR 3.3.3 Expansion versus intensification by dominant actor type

Table .32

Score	Description	1	2	3	4
1	Production increases only achieved by area increase (expansion). *(Unfavourable)*				
2	Production increases achieved by area increase (expansion) and some intensification.				
3	Production increases achieved equally by expansion and by intensification.				
4	Production increases achieved by intensification and some area increase (expansion).				
5	Production increases only achieved by intensification. *(Favourable)*				

INPUT INDICATOR 3.3.3 Expansion versus intensification by dominant actor type
Rationale: Production increase may be realized by expansion (more area cultivated), or by intensification (higher productivity per area). Area expansion requires much natural resources and loss of biodiversity is the result. Intensification may lead to pollution of natural ecosystems nearby.

INPUT INDICATOR 3.3.4 Productivity per unit of land or resource by dominant actor type

Table .33

Score	Description	1	2	3	4
1	Very low productivity per unit of resource (land, water) – relatively very low yields, inefficient production systems, loss of resources, many wastes, … *(Unfavourable)*				
2	Low productivity per unit of resource (land, water) – relatively low yields, etc.				
3	Moderate productivity per unit of resource (land, water) – average yields, etc.				
4	High productivity per unit of resource (land, water) – high yields, etc.				
5	Very high productivity per unit of resource (land, water) – very high yields, etc. *(Favourable)*				

INPUT INDICATOR 3.3.4 Productivity per unit of land or resource by dominant actor type
Rationale: Low productivity per unit of resource implies inefficient use of natural resources and low profitability and income.

INPUT INDICATOR 3.3.5 Level of capacities and skills by dominant actor type

Table .34

Score	Description	1	2	3	4
1	Very low level of capacities, skills development, specialized labor, training, …. *(Unfavourable)*				
2	Low level of capacities, skills development, specialized labor, training, ….				
3	Moderate level of capacities, skills development, specialized labor, training, ….				
4	High level of capacities, skills development, specialized labor, training, ….				
5	Very high level of capacities, skills development, specialized labor, training, …. *(Favourable)*				

INPUT INDICATOR 3.3.5 Level of capacities and skills by dominant actor type
Rationale: A low level of education and knowledge, capacities and skills is an unfavourable situation for innovation and efficient production systems.

Annex 3 Selected outcome indicators as used in the case studies

Selected outcome indicators as used in the case studies **Table A3.1**

Case / Outcome indicator	Change in Biodiversity	Change in Goods	Change in Human well-being	Change in Poverty
Brazil	Change in MSA calculated with GLOBIO3 model on the basis of five pressures on biodiversity	Change in area and productivity of cultivated land	Change in: HDI, GDP per capita in current Real & compared to national average, employment, food security; equality; Number of land conflicts	Number of people below 25% (extreme poverty) and 50% (poverty) of minimum salary, compared to national average
Costa Rica	Change in MSA on the basis of habitat loss and land-use intensity	Change in area and productivity of cultivated land + forest activities and tourism	Change in: HDI, GDP per capita in US$	% of families with income below US$ 66, below and above US$ 132 per month
Ecuador	Change in MSA on the basis of habitat loss and land-use intensity	Change in area of cropland and pasture	Change in income per capita	Change in: HPI, number of poor people, child malnutrition rate compared to national average
Indonesia	Change in MSA calculated with GLOBIO3 model on the basis of five pressures on biodiversity	Increase in crop area for the production of palm oil	Change in HDI; GINI compared to national average	Change in: HPI compared to national average, child malnutrition
Mali	Change in Pressures: area of agricultural land, number of farms and tree cover; Overexploitation by herds; Harvesting and hunting.	Change in: feed production in sylvo-pastural area, area of cropland and productivity of the soil, i.e. cotton yields per ha and % organic matter in top-soil, number of cattle; Average annual wood-cut per person per year.	Prices of cotton and maize; Change in: incomes, number of larger farms with high incomes, rural population	Change in frequency of farm types; Number of poor farms
Mexico	Change in MSA on the basis of habitat loss and land-use intensity	Land-use change; Land abandonment because of erosion and low prices; Regrown forest used for gathering; Change in production	Change in: housing conditions, access to drinking water system, electrification, health care services	HPI compared to national average; Change in number of poor people; Migration of poor people
Nicaragua	Change in MSA on the basis of habitat loss and land-use intensity Change in area of primary forest and secondary forest; Fragmentation of primary forest; Disappearance of key species	Change in: area of pasture + cropland, productivity in goods and in US$ per ha per year; Disappearance of bush meat	Change in GDP per capita; GINI; Access to social services, institutional capacity and local government	Change in: hunger, child mortality, daily animal protein intake, number of poor people; Immigration of poor people.
Vietnam mangrove	Change in MSA on the basis of habitat loss and land-use intensity	Change in: production of shrimp, clam and crab, economic activity, share of income from aquaculture and shrimp farming, population involved with aquaculture; Share of income from exploitation of mangrove per income class	Change in: annual household income in Vietnamese Dong, GDP growth rate.	Change in: HPI, percentage of poor households, hunger
Vietnam shifting cultivation	Change in forest quality: area of rich and poor forest and forest plantation, forest cover.	Change in: share of income from forestry and non-timber forest product, exploitable timber stock, extent and productivity of crop area, irrigated area, livestock numbers.	Change in: food production per capita in rice equivalents, healthcare, education; Standard of living compared to national average	Change in poverty rate
Ghana	Change in Marine Trophic Index (MTI)	Change in: total catch, number of canoes.	Change in: catch per capita, consumption per capita	Rural poverty rates compared to other rural poverty rates
Kenya	Change in species diversity index	Change in total catch compared to the estimated maximum sustainable yield, catch per unit effort, mesh size and average size of fish.	Change in catch per boat per day for Nile perch destined for factory processing	Change in income per fisherman; Food expenditure to meet the daily family needs

Annex 4 Glossary

Sources: Millennium Ecosystems Assessment (2005a) and UNEP/CBD/SBSTTA/3/INF.13 (2003), except specifically mentioned.

Assessment
The analysis and review of information derived from research for the purpose of helping someone in a position of responsibility to evaluate possible actions, or think about a problem. Assessment means assembling, summarizing, organizing, interpreting, and possibly reconciling pieces of existing knowledge, and communicating them so that they are relevant and helpful to an intelligent but inexpert decision-maker. (Parson, 1995).

Baseline
Starting point (a certain date or state) against which the changes in the condition of a variable or set of variables are measured.

Biodiversity loss
The long-term or permanent qualitative or quantitative reduction in components of biodiversity and their potential to provide goods and services, to be measured at global, regional and national levels.

Source: https://cbd.int/doc/meetings/bs/bswglr-01/information/bswglr-01-inf-02-en.doc .

Biotic homogenization
- The replacement of local organisms by exotic species that can co-exist with humans.
- As a result of human interventions the abundance of many native species decrease ('losers') while the abundance of a few other –often human favored species ('winners') – increases. Consequently ecosystems become more and more alike (Ten Brink, 2000).
- Process by which the differences between biotic communities in different areas are on average reduced.

Biological Diversity or Biodiversity
The variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

Brittle and non-brittle ecosystems
Brittleness is the pattern of distribution of moisture in all forms through the year. Non-brittle ecosystems have regular distribution of moisture (whether rain, snow, or humidity) throughout the seasons." At the other extreme of the continuum, "brittle" environments have very different characteristics with irregular uneven distribution of moisture during the year. A scale of 1 (extremely non-brittle) to 10 (extremely brittle) may be used to describe the degree of brittleness. (Allan Savory; www.managingwholes.com). Brittleness was taken as a proxy for the sensitivity of the ecosystem to degradation and the lack of capacity to resilience from perturbation.

DPSIR-causal effect chain
- Driving force (indirect drivers of change, such as population growth and consumption)
- Pressure (direct drivers of change, such as acidification, land conversion, and hunting)
- State (condition of studied subject, such as biodiversity, and water, soil and air quality)
- Impact (how the change in the state affect people in socio-economic or health terms)
- Response (the measures taken by man to change D-P-S or I
- DPSIR are sequential steps in the effect-chain. They all have a past, present and future value.

Determinant
A factor which highly determines the value of the outcome indicators of poverty and biodiversity in the majority of the case studies.

Ecosystem services
- Ecosystem functions are all those processes and products delivered by ecosystems, the 'fabric of life on Earth'. We consider G&S as those ecosystem functions which directly or indirectly benefit man. The Millennium Ecosystem Assessment distinguishes supporting, provisioning, regulating and cultural services.
- *Provisioning services* such as food and water;
- *regulating services* such as flood and disease control;
- *cultural services* such as spiritual, recreational, and cultural benefits; and
- *supporting services* such as nutrient cycling that maintain the conditions for life on Earth.
- The concepts "ecosystem goods and services" and "ecosystem functions" are synonymous with ecosystem services.

Farming system
A farming system is defined as a population of individual farm systems that have broadly similar resource bases, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate. Depending on the scale of the analysis, a farming system can encompass a few dozen or many millions of households (Dixon et al., 2001).

GLOBIO3 biodiversity model
The GLOBIO3 model measures habitat integrity through remaining species-level diversity in terms of mean species abundance of the original species (MSA). At the heart of GLOBIO3 is a set of regression equations relating degree of pressure to degree of impact (dose-response relationships). The dose-response relationships are derived from the database of biodiversity response to change. Where possible, relationships for each pressure are derived for biome and region – depending on the amount of available data (CBD-MNP 2007).

Human Development Index (HDI)
The human Development is a composite indicator of Human Development (HDR, 2002) on the basis of three basic dimensions:
- a long and healthy life (life expectancy)
- knowledge (adult literacy and primary, secondary and tertiary gross enrollment ratio
- a decent standard of living: GDP per capital at purchasing power parity in US dollars.

Human Poverty Index (HPI)
The human poverty index is a composite indicator for the state of deprivation on human wellbeing for three basic domains:
- possibility at birth of not surviving to age 40;
- adult illiteracy rate
- children under weight for age and population without sustainable access to improved water source.

Human well-being
Human well-being captures people's living condition, quality of life or human development. According to the MEA (2003) human well-being is determined by five dimensions: basic material for a good life, freedom and choice, health, good social relations and security.

Hunger
A condition in which people lack the basic food intake to provide them with the energy and nutrients for fully productive, active life and is an outcome of food insecurity (FAO, 2004).

Infant Mortality Rate
Deaths of children under one or five year old per 1000 live births.

Livelihood
Activities, assets (material and social resources), and access that jointly determine the living gained by an individual or household compose a livelihood. While livelihoods are generally associated with monetary or material rewards, poor people also use the concept to refer to less tangible benefits like a sense of greater social acceptance or of being more empowered.

A focus on livelihoods, as Farrington et al. (1999) explain, puts emphasis on: people and their activities, the holistic nature of people's activities and the links between the micro and macro (www.idrc.ca/en/).

Man-made ecosystems
Heavily modified areas intensively used and managed by humans such as cropland, permanent agriculture, infrastructure, artificial waters such as ditches and canals and industrial and mining area, including (semi)natural elements within these areas.

MSA
Mean Species Abundance of original species compared to the natural or low-impacted state (Alkemade et al., 2009), calculated by the GLOBIO3 biodiversity model.

Poverty
Poverty is an undesired state of human well-being, measured as a score below a certain level of human well-being (Sen, 1999).

Poverty headcount
Poverty headcount is the number of people with an income below the national or international poverty line (absolute number).

Poverty rate
Poverty rate is the percentage of the population with an income below the poverty line (a relative number).

Poverty reduction
Poverty reduction is any process which seeks to reduce the level of poverty in a community, or amongst a group of people or countries.

Reporting unit of the case study area
The spatial and temporal units at which the case study assessment and the analysis of findings are reported.

Resource user
Household level economic unit that depends on agricultural, livestock, fisheries, timber or non-timber-forest production for their livelihood or family income.

Scale
- Spatial scale: exact area of subject; exact area on which the indicator is applied to
- Temporal scale: the time period on which the indicator is applied to
- The measurable time and spatial dimensions of phenomena or observations. Expressed in physical units, such as meters, years,
- In observation, scale determines the relative fineness and coarseness of different detail and the selectivity among patterns these data may form.

Species abundance
The number of individuals of a species, which may be measured in various ways such as biomass, density, total numbers, distribution, breeding pairs, etc.

Species diversity
Diversity at the species level, often combining aspects of species richness and their relative abundance.

Stakeholders
Person, group, organization, or system who affects or can be affected by an organization's actions. Key stakeholders in a business organization include creditors, customers, directors, employees, government (and its agencies), owners (shareholders), suppliers, unions, and the community from which the business draws its resources.

Stunting
Stunting is chronic undernutrition measured by low length for age among children under five years old.

Sustainability
A characteristic or state whereby the needs of the present and local population can be met without compromising the ability of future generations or populations in other locations to meet their needs.

Sustainable use (of an ecosystem)
Human use of an ecosystem so that it may yield a continuous benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations.

Trophic level
The average level of an organism within a food web, with plants having a trophic level of 1, herbivores 2, first-order carnivores 3, and so on.

Use system
Use systems are exploitation of natural resources such as hunting, gathering and fishery or the conversion of natural habitat into cropping, grazing and forestry production systems. (see also farming system).

Vulnerability
Vulnerability is the exposure to contingencies and stress, and the difficulty in coping with them. Three major dimensions of vulnerability are involved:

- exposure to stresses, perturbations, and shocks;
- the sensitivity of people, places, ecosystems, and species to the stress or perturbation, including their capacity to anticipate and cope with the stress;
- and the resilience of ecosystems and species in order to recover from shocks and the adaptive capacity of people in terms of their capacity to absorb shocks.

Annex 5 Contact persons of research partners who carried out the case studies

Contact persons of research partners who carried out the case studies Table A3.1

Case study country & region	Institute	Contact person	Website
Brazil *El Cerrado*	AIDEnvironment	Jan Joost Kessler	www.aidenvironment.org
Indonesia *Kalimantan*	AIDEnvironment	Jan Joost Kessler	www.aidenvironment.org
Costa Rica *Hojancha*	Centro Agronómico Tropical de Investigación y Enseñanza (CATIE)	José Joaquín Campos	www.catie.ac.cr
Ecuador *Cotopaxi*	Fundación Equatoriana de Estudios Ecológicos (Ecociencia)	Malki Sáenz	www.ecociencia.org
Ghana *Coast*	Fisheries; UBC University of Britisch Columbia	Jackie Alder	www.fisheries.ubc.ca
Kenya *Lake Victoria*	Kenia Wildlife Service (KWS), Maxillion Univerisity and WWF Kenya	Richard Odongo (†) and J.O. Manyala	www.kws.go.ke
Mali *Koutiala*	AIDEnvironment	Tjark Struif Bontkes and Jan Joost Kessler	
Mexico *Chiapas*	CIMMyT (Centro de Investigación Mundial de Maíz y Trigo) & ECOSUR (El colegio de la Frontera Sur)	Jonathan Hellin and Adriana Rios	www.*cimmyt*.org and www.ecosur.mx
Nicaragua *Chontales*	Area de Desarrollo Agrario y Rural - Universidad Centroamericana (UCA/ADAA)	Rolando Mena	www.uca.edu.ni/programas/adaa/index.html
Vietnam *Dakrong District*	Centre for Natural Resources and Environmental Studies (CRES)	Hoc Truong Quang	www.cres.edu.vn
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How do biodiversity and poverty relate?

Decision makers face this challenging question when they explore ways of simultaneously achieving the Millennium Development Goals and the CBD 2010 targets for biodiversity conservation. Reducing poverty while conserving biodiversity – a 'win-win' – can be reached locally. However, such a positive impact is hard to realise if all trade-off effects elsewhere and in the future are considered. Most resource-use systems follow a similar pattern. Decreasing poverty coincides with decreasing biodiversity, creating a 'win-lose' situation, up to a certain threshold. Then, the correlation shifts to increasing poverty with decreasing biodiversity, and becomes 'lose-lose'.

The relationship between biodiversity and poverty largely knows 16 determinants, characterising socio-economic context, ecosystems and production processes. Market integration, access to capital, management skills and productivity divide all cases into two types of resource-use system: market-oriented and capital-driven, or subsistence-oriented and poverty-driven. How these determinants influence biodiversity and poverty also depends on cross-cutting factors, such as population density and growth, ecosystem sensitivity to degradation, governance, and policies on poverty alleviation and biodiversity protection. Policy interventions may shift negative trends towards a more positive direction, making them policy driven.