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Report 106

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Plant Research International B.V., Wageningen
August 2005

Report 106

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Preface

This report is written as part of the DLO North South program 404 in collaboration with the National Institute for Public Health and the Environment (RIVM). There is a strong need for a logical framework that links policy and scientific insights in order to support policy making on the relation between biodiversity conservation and poverty reduction. This demand results from the current global agreements on these issues: the Convention on Biological Diversity aims at reducing significantly the rate of global biodiversity loss by 2010, and the UN Millennium Development Goals has halving global poverty by 2015 as one of its aims.

Biodiversity and poverty are interrelated but our insights in these relations are haphazard and limited. There are no methodologies available to quantify trade-offs and synergies among both, nor a logical framework linking them. Therefore, this report aims to develop a framework linking poverty reduction and biodiversity conservation in order to identify relevant research questions contributing to improved policy formulation.

The framework provided in this report is a first step in organizing our knowledge on the topic of biodiversity and poverty. It serves a dual purpose. It is meant to feed the policy and scientific dialogues on biodiversity and poverty linkages and it is meant to develop a modeling tool for quantifying the trade-offs and synergies between these issues. Wageningen UR will pursue its collaboration with RIVM and other parties to further unravel this complex but globally important issue.

Abstract

This report aims to develop a framework linking poverty reduction and biodiversity conservation in order to identify research questions and to contribute to improved policy formulation. A general overview of the subject, definitions and concepts of poverty and biodiversity are described in Chapters 2 and 3.

Subsequently, we develop an analytical framework that comprises three components dealt with in Chapters 4-6. First, the relationship between poverty and biodiversity is described including their relationship with the abiotic and the economic-institutional environment. Land use is starting point for describing these relationships as major threats to biodiversity are related to the conversion of natural habitats into agricultural land while most poor households live in rural areas where agriculture is their major livelihood strategy. Second, we propose four scenarios illustrating the consequences of contrasting options reconciling biodiversity conservation and poverty reduction goals based on the described relationships. The scenarios are: (1) protected area, (2) buffer zone, (3) integrated sustainable development, and (4) exit scenario. The scenarios are linked to five poverty reduction strategies (i.e. intensification of production systems, diversification of production systems, expansion of land holdings, increase of off-farm income and outflow from agriculture), which supports the identification of research issues and appropriate policy instruments for interventions in each scenario. The scenarios differ in the way they assign priorities to poverty alleviation and biodiversity conservation, and thus in the required interventions and agricultural production systems to achieve objectives. Third, we characterize agricultural production systems based on a mix of a farming systems approach and production-ecological principles.

In the discussion and conclusions, a research agenda is proposed targeting the main research topics that come to the fore when applying this framework for analyzing the linkages between poverty and biodiversity through scenarios. The framework can be applied at various scales to perform model analyses for policy formulation. It can be used to analyze specific cases of regional developments, but it can also be used to explore trade-offs at global scale, though different modules and parameterization will be required.

1. Introduction

Earth's biodiversity, i.e. the richness of species of flora and fauna and the variety of ecosystems is seriously threatened. Current rates of extinction of species are estimated at 100 to 1000 times pre-human levels (Pimm *et al.*, 1995). Nature and causes of biodiversity loss are location-specific but, in general, can be ascribed to the 3.7–fold increase of the global population and the 4.6-fold increase in per capita gross domestic product during the last century (Maddison, 1995). The Millennium Ecosystems Assessment of the United Nations concluded that the major changes in ecosystems over the past 50 years were the direct or indirect result of changes made to meet growing demands for ecosystem services, in particular growing demands for food, water, timber, fiber, and fuel (fuelwood and hydropower) (MEA, 2005). While these changes have contributed to substantial net gains in human well-being and economic development, the degradation of ecosystems can in turn significantly harm future human well-being. The vulnerability of poor people who are generally most directly dependent on natural resources is likely to increase even further.

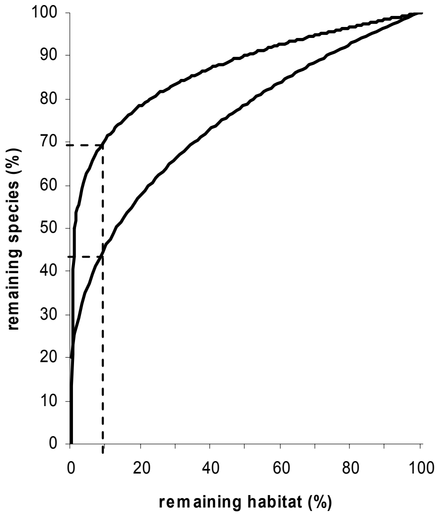
The current global population of 6 billion continues to grow, especially in developing countries. By the year 2030, global population is estimated to reach 8.3 billion with well-over 95% of the growth occurring in developing countries (FAO, 2003). The largest population increase will take place in biodiversity-rich countries. Currently, more than 1.1 billion people live within the 25 global diversity hotspots, described by ecologists as the most threatened species-rich regions on earth (Myers *et al.*, 2000). In 19 of these hotspots, population growth is more rapid than in the world as a whole (Cincotta & Engelman, 2000). In addition, the number of households in hotspot countries increases more rapidly than population growth due to a reduction in average household size (Liu *et al.*, 2003a). Smaller households are associated with higher per capita resource consumption. As a consequence, more people living in smaller households means an increased demand for food, feed and other commodities (e.g. fiber, wood, flowers) that have to be produced by agriculture. In addition, as incomes increase globally, people add more protein-rich meat and fish to their diet. This adds to the problem as the production of meat is less efficient in resource use than that of plant products and, hence, requires more scarce resources such as land, water and energy. FAO (2003) estimates that the world cereal production needs to grow by 50% in 2030 to meet the global consumption demand.

Agricultural development, conversion of natural land for agriculture, and conversion of agricultural land into urban sprawl are widely recognized as the most serious threats to the conservation of biodiversity and the loss and fragmentation of native habitats (Ehrlich & Ehrlich, 1981; Box 1). Habitat loss and degradation are the most important threats to species, affecting 23% of all assessed vertebrates, 57% of assessed invertebrates, and 70% of assessed plants (IUCN, 2004). Especially, tropical areas are rich in biodiversity, but are most vulnerable to habitat conversion and loss of biodiversity, due to increasing global demand for tropical products and growing human populations in those areas (Myers, 1984).

Rural poverty is concentrated in many of the areas with the richest and most endangered biodiversity. About 75% of the 1.2 billion poor worldwide, i.e. those living on less than US$ 1 per day, live in rural areas, primarily in the tropics (IFAD, 2001). Projections suggest that more than 50% will continue to do so in 2025. On the one hand, the fact that poverty is often associated with biodiverse environments may easily lead to the conclusion that poverty is a major threat to biodiversity conservation. This would suggest that economic development (reducing poverty) would favor the conservation of biodiversity. On the other hand, one could argue that the conservation of biodiversity is favored by poverty as the poor lack the assets and capital to endanger biodiversity on a wide scale (Wunder, 2001). In other words, economic development and associated claims on natural resources, even and especially from remote societies, threatens biodiversity in less developed and poor countries. The truth is bound to lie between these two extreme positions but they indicate roughly the different points of view in the debate.

Box 1

Relationship between habitat area and species number



When habitat area declines, greater proportions of species living within these habitats tend to become extinct. The relationship between habitat area and the number of species can be illustrated using so-called *species-area* curves. These curves have proven to be reliable predictors of decline in species numbers when habitat area is lost. Assuming that 100% of the species are found in a habitat size of 10.000 km^2, both species-area curves give the percentage of species lost from a region as the habitat area declines (Dobson, 1996). The curves of most groups of species tend to pass through the zone in the graph bounded by both curves. These curves suggest that when only 10% of the original habitat remains (vertical dotted line) between 45 and 70% of the original species remain. This means that the IUCN's goal of protecting 10% of each major habitat type would warrant the sustenance of approximately half of the species richness (IUCN, 1992).

Obviously the causal relationship between poverty and biodiversity runs in both directions. Poverty can force people to deplete natural resources around them, thus destroying the resource base upon which their incomes rely. Conversely, persistent natural resource degradation can contribute to poverty, particularly among subsistence farmers. This double-sided sword indicates the complex relationship between poverty and biodiversity. This complex relation is further affected by the external claims on natural resources relative to the local poor by wealthy people that can more effectively reap the benefits of resources, such as through advanced logging, or the production of feeds like soybean for animal production. These claims push poor people more and more into marginal regions.

Both poverty reduction and biodiversity conservation are at the top of the global agenda on sustainable development after the adoption of the Millennium declaration by the General Assembly of the United Nations (UN, 2000). The declaration resulted in the formulation of the so-called eight Millennium Development Goals (MDGs) of which one of the aims is the eradication of extreme poverty and securing environmental sustainability. These joined aims suggest that poverty alleviation and conservation of biodiversity are compatible variables, but considering the complex relations described before, the achievement of both goals simultaneously is most difficult and challenging.

This paper presents a framework on how to jointly address the objectives of poverty alleviation of local poor and biodiversity conservation with the aim to facilitate policy formulation and to contribute to a research agenda. For describing the linkages between biodiversity and poverty we take land use as starting point because major threats to biodiversity are linked to the intensity of agriculture, the conversion of natural habitats into agricultural land and the use of fuel wood, which are all the lifeline of the poor, most of whom live in rural areas. To this end, a production-ecological approach is pursued as this allows the development of a framework that describes a wide array of agricultural systems that resemble current farming systems.

First, we briefly describe definitions, objectives and indicators related to poverty (Chapter 2) and biodiversity (Chapter 3). In Chapter 4, we present a general framework describing the relationships between poverty and biodiversity within the context of land use. This framework contributes to a broader understanding of the complex relationships between poverty and conservation. In Chapter 5 different scenarios are visualized and presented to reconcile the needs for poverty reduction and conservation of biodiversity. For each scenario, associated research and policy topics are identified, and possible intervention instruments supportive in creating an 'enabling environment'. The production-ecological approach is described in Chapter 6, including the resulting agricultural systems. Chapter 7 describes the general conclusions and identifies cross-cutting research issues.

2. Poverty[1]

Poverty has various dimensions and is closely linked to well-being. Generally, poverty can be defined as the **extent to which households or individuals have sufficient resources or abilities to meet their needs**. This definition links to the concept of sustainable livelihoods in which individuals or households rely on a basket of assets (resources or abilities) which determine their activities (or livelihood strategies). The basket comprises human (health skills, education), natural (resources), physical (infrastructure, housing), financial (earnings, savings, etc,) and social (networks, influence) assets. A livelihood is sustainable when it can cope with and recover from stress and shocks, and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base. Poor households rely heavier on few assets only, primarily natural resources and social capital, compared to wealthier people with a more comprehensive and balanced basket, which makes the poor rather vulnerable to change and pressures. The high reliance on few assets, the high vulnerability and the unequal wealth distribution links poor households closely to biodiversity. In this paper, we take into account the concept of livelihood strategies as means to alleviate poverty but develop our framework for linking poverty and biodiversity based on natural resources.

Although poverty has various dimensions, it is usually measured by income or consumption. Poverty is, therefore, often defined as not having enough income to consume a minimum level of basic food items. However, there are also non-monetary dimensions to poverty such as health, nutrition, literacy, social relations, security or other measures that may be related to subjective or personal values relating to how people experience poverty. Lack of these assets may hinder poor people to escape from poverty as it limits their choice in livelihood strategies. Lack of assets is an important aspect of poverty and is often related to poor income and low consumption.

When measuring poverty, targets have to be set that define threshold levels below which a person or a household is considered as being poor. This level is usually called the ‘poverty line’, expressed as a certain level of income. But targets can be set for non-monetary dimensions of poverty as well, such as the nutritional status of children, or the literacy rate of adults. Poverty lines can be absolute – i.e. an absolute standard of items that a households should be able to attain in order to meet their basic needs. For monetary measures, these absolute poverty lines are often based on estimates of the cost of basic food needs (i.e., the cost a nutritional basket considered minimal for the healthy survival of a typical family), to which a provision is added for non-food needs. But poverty lines may also be measured in relative terms – in relation to the overall distribution of income or consumption in a country. For developing countries, considering the fact that large shares of the population survive with the bare minimum or less, it is often more relevant to rely on an absolute rather than a relative poverty line.

2.1 Poverty reduction targets and indicators

The first MDG calls for a 50% reduction of people living on less than US$1 a day in 2015 relative to 1990, i.e. from 28% to 14% of all people in low and middle income economies. The Goals also call for halving the proportion of people who suffer from hunger between 1990 and 2015. Hunger and poverty are closely related indeed. Geographically, most poor and hungry are found in rural areas despite the fact that they are the locus of food production. Also development wise, hunger and poverty are connected. While the lack of sufficient income to purchase food is clearly a major factor causing household food insecurity, hunger itself contributes to poverty by lowering labor productivity, reducing resistance to disease and depressing educational achievements. In linking biodiversity and poverty, hunger should be considered in addition to agricultural use of land.

1 Use has been made of the work on poverty by the World Bank (WB, 2004).

In addition to income as related to poverty, the UNs Human Development Index (HDI) takes into account additional dimensions of wellbeing (or human development). The HDI is a summary measure of human development. It measures the average achievements in a country in three basic dimensions of human development:

- A long and healthy life, as measured by life expectancy at birth
- Knowledge, as measured by the adult literacy rate (with two-thirds weight) and the combined primary, secondary and tertiary gross enrolment ratio (with one-third weight)
- A decent standard of living, as measured by GDP per capita (PPP US$).

For its HDI, the UN uses three targets to measure poverty and progress towards the MDGs in developing countries: US$1 a day, US$2 a day and a national poverty line for developing countries. For developed countries, it uses three different targets: 50% of median income[2], US$11 a day (based on US poverty line) and US$4 a day. Although the US$1 a day poverty line is the most widely used, for different purposes it can be more useful to use a different, less stringent poverty line. The target of US$1 dollar a day has been criticized for being too arbitrary, not meaningful and unreliable (Reddy & Pogge, 2003). However, it has political appeal because of its simplicity and transparency. On the one hand poverty lines need to reflect the real issues at stake concerning poverty, on the other hand, for policy reasons, they need to be measurable, and preferably simple to understand. A balance is needed between the two (Box 4).

Once a poverty line has been set, there are three common methods to express poverty:

- Incidence of poverty (headcount index): This is the share of the population whose income or consumption is below the poverty line, i.e., the share of the population that cannot afford to buy a basic basket of goods.
- Depth of poverty (poverty gap): This measure captures the mean aggregate income or consumption shortfall relative to the poverty line across the whole population. It is obtained by adding up all the shortfalls of the poor (the non-poor having a shortfall of zero) and dividing the total by the population[3].
- Poverty severity (squared poverty gap): This indicator gives a higher weight to those individuals who are further away from the poverty line and, therefore, accounts also for the inequality among the poor.

Relative poverty measures are important to assess inequality. Inequality can be analyzed at different levels: country, region or population group. Inequality measures can be calculated for any distribution, not just for consumption, income or other monetary variables, but also for land and other continuous and cardinal variables. The most common measure of inequality is the Gini coefficient.

2.2 Strategies for reducing poverty

Our views on how to achieve poverty reduction has changed over the past decades (Ellis & Biggs, 2001). From an exclusive focus on (small-scale) agriculture a new paradigm is arising that views agriculture as a sector that positions itself along with a host of other actual and potential rural and non-rural activities that are important to the creation of viable rural livelihoods, without undue preference being given to farming as the unique solution to rural poverty. The livelihood approach with its basket containing different types of assets is an off-spring of this shift in thinking. Still, the high reliance of poor households on natural resources calls for a closer examination of this asset base. Since the 1980s natural resource management has become important, while the emphasis over time has shifted from minimizing adverse environmental externalities associated with agricultural activities and rural population to a more integral management of natural resources to the benefit of rural livelihoods. In this regard, pro-poor conservation has evolved, which aims to combat poverty while conserving natural resources. Although there has been a growing body of literature on pro-poor conservation (e.g. Roe *et al.*, 2003), the effect of different poverty reduction strategies on biodiversity has not been thoroughly described (Bojö & Reddy, 2003) nor investigated[4].

2 Poverty line is measured at 50% of equivalent median adjusted disposable household income.
3 A similar method can be used for non-monetary indicators (such as illiteracy), provided that the measure of the distance is meaningful.
4 Although the relationship between rural poverty reduction and the (loss of) agro-biodiversity is briefly examined by IFAD (2001).

With over 70% of the poor living in rural areas and depending on agriculture or agriculture-related activities it is justified to relate poverty reduction strategies to the agricultural sector. Moreover, in the context of biodiversity, and the direct claims on land for agriculture and biodiversity, we do not address urban dwellers. Their impact on biodiversity is considered to be indirect through the rural population and the need for agricultural products.

The FAO has identified five main strategies to improve livelihoods of farm households (Dixon *et al.*, 2001):
1. Intensification of existing production systems
2. Diversification of production and processing
3. Expansion of land holding or herd size
4. Increase of off-farm income, both agricultural and non-agricultural
5. Complete exit from the agricultural sector and within a particular farming system

These strategies all have different effects on biodiversity through linkages to be described in Chapter 4. The first three strategies pertain to agricultural activities. Intensification of existing production systems means that comparable or higher yields are attained with the same amount of land and a higher and improved use of inputs (such as fertilizer, improved varieties, better farm management). Diversification implies adjustments of activity patterns to increase farm income and reduce income variability. Expansion implies the expansion of the land holding by expanding managed resources.

Off-farm employment may refer to employment opportunities in agriculture and outside the agricultural sector. Remittances from off-farm work can be an important source of income for rural households. Off-farm employment may cause rural people to abandon their land altogether and exit from agriculture.

3. Biodiversity

At the 1992 Earth Summit in Rio de Janeiro, world leaders agreed on a comprehensive strategy for 'sustainable development' – meeting needs of the current generation while ensuring a healthy and viable world for future generations. This strategy is also known as the 'Agenda 21' indicating the long–term plan of action for the 21st century. One of the key agreements adopted at Rio was the Convention on Biological Diversity (CBD, 1992). This treaty sets out commitments for maintaining the world's ecological foundations and was rectified by the vast majority of world's governments. The treaty is legally binding and countries that signed the agreement are obliged to implement its provisions.

The Convention formulated three goals: **the conservation of biological diversity**, **the sustainable use of its components**, and **the fair and equitable sharing of the benefits from the use of genetic resources**. The definition of biodiversity as used in the context of the CBD is given in Box 2. In this paper we use this well-accepted definition as a starting point.

Box 2

Definition of biodiversity

Biological diversity – or biodiversity - is defined as the variability among living organisms from all sources including, *inter alia*, terrestial, marine and other aquatic ecosystems, and the ecological complexes of which they are part; this includes diversity between species, within species and of ecosystems. First, biodiversity is understood in terms of the wide variety of plants, animals and micro-organisms. Second, biodiversity also includes genetic differences within each species - for example, between varieties of crops and breeds of livestock. The third aspect of biodiversity is the variety of ecosystems such as those that occur in deserts, forests, wetlands, mountains, lakes, rivers, and agricultural landscapes. Ecosystems are considered as the dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit. This definition does not specify any particular spatial unit or scale, thus the term 'ecosystem' can refer to any functioning unit at any scale. The scale of analysis (and action) should be determined by the problem being addressed. It could, for example, be a grain of soil, a pond, a forest, a biome, or the entire biosphere.

The Convention is different from previous conservation efforts aimed at protecting particular species and habitats as it recognizes that genes, species and ecosystems must be used for the benefit of humans. Two out of three objectives refer explicitly to the use of biodiversity by humans suggesting a link between biodiversity and development. Biodiversity comprises one of the resources on which individuals, households, and society depend for satisfying basic needs. Conditions of the Conventions should guarantee that the exploitation of biodiversity is done in a way and at a rate that does not result in its long-term decline.

3.1 The function of biodiversity

The structure and processes of ecosystems are the pillars upon which civilizations are built, such as filtering and retention of fresh water, breakdown of toxic compounds, and conversion of solar energy into edible plants. These ecological structures and processes can be classified into four main ecosystem functions, i.e., *regulation*, *habitat*, *production* and *information*, where an ecosystem function can be defined as the capacity of ecological processes and components to provide goods and services that satisfy human needs directly or indirectly (De Groot *et al.*, 2002). In short, regulation functions involve the capacity of ecosystems to regulate processes through bio-chemical cycles and other biospheric processes. Habitat functions refer the provision of refuge and reproduction habitat to species. Production functions are mainly of importance for the provision of ecosystem goods for human consumption and involve processes such as photosynthesis and nutrient uptake by plants. Information functions are less tangible but comprise those processes and components required for providing, for example, aesthetic, recreation, spiritual and education services. Examples of ecosystem functions and the goods and services they provide are shown in Box 3. De Groot *et al*. (2002) present a comprehensive but by no means complete list of functions, goods and services.

Box 3

Examples of goods and services provided by ecosystem functions (De Groot *et al.*, 2002)

Ecosystem function:	*Goods and services:*
Gas regulation	UVb protection, influence on climate
Water supply	Provision of water for consumptive use
Waste treatment	Pollution control, filtering of dust particles
Soil formation	Maintenance of productivity on arable land
Refugio	Maintenance of biological and genetic diversity
Food production	Hunting, fishing, agriculture
Raw materials production	Fuel, energy, building material, fodder, fertilizer
Medicinal resources	Health care, drugs and pharmaceuticals
Aesthetic information	Enjoyment of scenery
Recreation	Eco-tourism

The loss of biodiversity affects the performance of functions and reduces the ability of ecosystems to provide many of the goods and services that satisfy human needs. Replacement of goods and services is often extremely costly or even impossible, such as in the case of the extinction of species. Therefore, the Convention on Biological Diversity adopted the precautionary principle, i.e. lack of scientific certainty should not be used as a reason for postponing measures to avoid or minimize threats of significant reduction or loss of biological diversity (CBD, 1992).

3.2 Measuring biodiversity

Since biodiversity is such a broad, multidimensional concept, it is not easy to determine indicators for measuring its status and trend. Appropriate indicators are required to assess biodiversity performance and to identify key policy issues to be addressed through interventions and other actions, such as research, awareness raising, etc. Biodiversity indicators are also important to facilitate communication between policy-making, science and society at large. Policy defines targets and measurable objectives, while scientists need to determine relevant variables of biodiversity, monitor current state and develop approaches to make projections of future biodiversity status. Information on indicators also directs monitoring and research programs (Box 4).

Box 4

Requirements for biodiversity indicators (based on OECD, 2003)

- *Policy relevance,* i.e. addressing policy objectives so that progress in attaining these goals can be tracked effectively.
- *Analytical soundness* being based on sound science but acknowledging that their development is an evolving process.
- *Measurability* in terms of data availability and cost effectiveness of data collection, and
- *Interpretation*, i.e. indicators should provide essential information to policymakers, researchers and the wide public in a way that is clear and easy to understand.

Progress in developing generic and practical sets of indicators for biodiversity is slow due to scientific uncertainty, such as the poor understanding of ecosystem processes and functions. In addition, the wide range of goods and services provided by ecosystems and associated goals require several indicators to allow evaluation of progress in their realization. As a consequence, many different individual indicators need to be considered that fulfill criteria such as set out in Box 4. Composite indicators as often used in socio-economic sciences are urgently needed to make progress in measuring and assessing the status of biodiversity. Eaton and colleagues (in prep.), for instance, have contributed to the international debate on indicator development by analyzing the value of available indicators for policy purposes and by identifying a more comprehensive set of indicators for cost-effective monitoring and evaluation of conservation strategies and activities.

3.3 Biodiversity goals and targets

In response to the accelerated rate of biodiversity loss, ten years after the Convention on Biological Diversity was open for rectification, a strategic plan was formulated in 2002 for a more efficient and coherent implementation of the three broad objectives of the Convention, i.e. the conservation of biodiversity, the sustainable use of its components and the fair and equitable sharing of benefits from the use of genetic resources. This strategic plan identifies eleven goals and twenty-one targets which are grouped into seven so-called focal areas (Box 5). This framework should enable the evaluation of achievements and progress in 2010 towards realizing a significant reduction of the current rate of biodiversity loss at the global, regional and national level. Goals and targets are not fixed but need to be developed according to national priorities and capacities, taking into account differences in diversity between countries.

Box 5

2010 Biodiversity goals and targets for focal area (CBD, 2004)

Focal Area 1: Protect the components of biodiversity

Goal 1. Promote the conservation of the biological diversity of ecosystems, habitats and biomes

- Target 1.1: At least 10% of each of the world's ecological regions effectively conserved.
- Target 1.2: Areas of particular importance to biodiversity protected.

Goal 2. Promote the conservation of species diversity

- Target 2.1: Restore, maintain, or reduce the decline of populations of species of selected taxonomic groups.
- Target 2.2: Status of threatened species improved.

Goal 3. Promote the conservation of genetic diversity

- Target 3.1: Genetic diversity of crops, livestock, and of harvested species of trees, fish and wildlife and other valuable species conserved, and associated indigenous and local knowledge maintained.

Box 5 (continued)

Focal Area 2: Promote sustainable use

Goal 4. Promote sustainable use and consumption
- Target 4.1: Biodiversity-based products derived from sources that are sustainably managed, and production areas managed consistent with the conservation of biodiversity.
- Target 4.2: Unsustainable consumption, of biological resources, or that impacts upon biodiversity, reduced.
- Target 4.3: No species of wild flora or fauna endangered by international trade.

Focal Area 3: Address threats to biodiversity

Goal 5. Pressures from habitat loss, land use change and degradation, and unsustainable water use, reduced
- Target 5.1: Rate of loss and degradation of natural habitats decreased.

Goal 6. Control threats from invasive alien species
- Target 6.1: Pathways for major potential alien invasive species controlled.
- Target 6.2: Management plans in place for major alien species that threaten ecosystems, habitats or species.

Goal 7. Address challenges to biodiversity from climate change, and pollution
- Target 7.1: Maintain and enhance resilience of the components of biodiversity to adapt to climate change.
- Target 7.2: Reduce pollution and its impacts on biodiversity.

Focal Area 4: Maintain goods and services from biodiversity to support human well-being

Goal 8. Maintain capacity of ecosystems to deliver goods and services and support livelihoods
- Target 8.1: Capacity of ecosystems to deliver goods and services maintained.
- Target 8.2: Biological resources that support sustainable livelihoods, local food security and health care, especially of poor people maintained.

Focal Area 5: Protect traditional knowledge, innovations and practices

Goal 9. Maintain socio-cultural diversity of indigenous and local communities
- Target 9.1: Protect traditional knowledge, innovations and practices.
- Target 9.2: Protect the rights of indigenous and local communities over their traditional knowledge, innovations and practices, including their rights to benefit sharing.

Focal Area 6: Ensure the fair and equitable sharing of benefits arising out of the use of genetic resources

Goal 10. Ensure the fair and equitable sharing of benefits arising out of the use of genetic resources
- Target 10.1: All transfers of genetic resources are in line with the Convention on Biological Diversity, the International Treaty on Plant Genetic Resources for Food and Agriculture and other applicable agreements.
- Target 10.2: Benefits arising from the commercial and other utilization of genetic resources shared with the countries providing such resources.

Focal Area 7: Ensure provision of adequate resources

Goal 11. Parties have improved financial, human, scientific, technical and technological capacity to implement the Convention
- Target 11.1: New and additional financial resources are transferred to developing country Parties, to allow for the effective implementation of their commitments under the Convention, in accordance with Article 20.
- Target 11.2: Technology is transferred to developing country Parties, to allow for the effective implementation of their commitments under the Convention, in accordance with its Article 20, paragraph 4.

Identification and formulation of more explicit goals than the CBDs founding objectives is an important step in monitoring progress in reducing biodiversity loss. However, identification of indicators that fulfill criteria as defined in Box 4 and allow to measure progress in realizing each of the defined targets is complex and has not yet been achieved (Balmford *et al.*, 2005). The associated lists of indicators as part of the strategic plan concerns a provisional and incomplete set as it comprises only 8 indicators while 21 targets are identified (Box 6). In addition, identified indicators are considered ready for immediate testing which suggests that their usefulness or implementation is still uncertain. The list of possible indicators comprises 13 indicators but is rather a research agenda than a practical guide for using these indicators for monitoring and evaluation. In short, progress in the identification of appropriate indicators is slow and, therefore, hampers the realization of targets as set by the CBD for various goals.

Box 6

Provisional set of indicators for assessing progress towards the 2010 biodiversity targets

Focal area	Indicator for immediate use	Possible indicator for development
Protect components of biological diversity	• Trends in extent of selected biomes, ecosystems and habitats • Trends in abundance and distribution of selected species • Coverage of protected areas	• Change in status of threatened species (Red List indicator under development) • Trends in genetic diversity of domesticated animals, cultivated plants, and fish species of major socio-economic importance
Sustainable use		• Area of forest, agricultural and aquaculture ecosystems under sustainable management • Proportion of products derived from sustainable sources
Threats to biodiversity	• Nitrogen deposition	• Numbers and cost of alien invasions
Goods and services from biodiversity	• Marine trophic index • Water quality in aquatic ecosystems	• Application to freshwater and possibly other ecosystems • Connectivity/fragmentation of ecosystems • Incidence of human-induced ecosystem failure • Health and well-being of people living in biodiversity-based-resource dependent communities
Protect traditional knowledge, innovations and practices.	• Status and trends of linguistic diversity and numbers of speakers of indigenous languages	• Further indicators to be identified by WG-8j
Fair and equitable benefit-sharing		• Indicator to be identified by WG-ABS
Ensure status of resource transfers	• Official development assistance provided in support of the Convention	• Indicator for technology transfer

4. Linkages between biodiversity and poverty

Starting point is the framework in which functions of natural habitats and rural areas, their relationship and their relationships with the abiotic and economic-institutional domain are described (Figure 1). Underlying causes may be different but in many cases competition between conservation and poverty goals concern spatial claims both for terrestrial and aquatic ecosystems. Therefore, we distinguish in the framework natural habitats and rural areas. With the natural habitats we indicate the *biodiversity domain*. We use the term natural habitat rather than biodiversity as it has an explicit spatial connotation in contrast to biodiversity. Natural habitats provide living space for wild plants and animals and, therefore, form the basis for most other ecosystem functions (Box 3). With rural areas we typify the *domain of poor farm households* (poverty) of which the majority depends on agricultural activities as their major livelihood strategy. We use the term rural areas as it has a spatial connotation in contrast to households. Farm households possess various assets such as labor, land, and capital (human, physical, and social) which are used to undertake activities, such as food production, providing labor and drought oxen to third parties to generate income to satisfy their consumption, nutrition, health and education needs. For analytical purposes, we have separated biodiversity (natural habitat) from poor farm households (rural areas) in the framework. In practice they are mixed and part of the same ecosystem. We mainly use the framework to analyze spatial claims related to conservation and poverty, but the framework may likewise be used to analyze the relationship between soil depletion (biodiversity) and reduced agricultural productivity (poverty), or between climate change and poverty.

Natural habitats and rural areas are part of the **abiotic environment** comprising natural resources such as water, land, nutrients and climate. The **economic and institutional environment** provides markets, infrastructure, public services and non-agricultural employment opportunities. Policy uses the economic and institutional environment to influence both conservation and poverty. More in general and using the framework terminology, changes in the economic-institutional environment will have an impact on both natural habitats and rural areas.

Different components of the framework are interlinked, which is indicated by the arrows in Figure 1. The first relation **(1)** is between natural habitats and the abiotic environment. On the one hand, the abiotic environment provides land, water, nutrients to and determines the climate of natural habitats. On the other hand, natural habitats affect the quantity and quality of the abiotic environment through their different functions, such as climate and gas regulation by tropical forests.

The abiotic environment provides natural resources to farm households to produce food and other agricultural products **(2)**. Therefore, competition between natural habitats and rural areas relates to claims on land, water and nutrients, while their effect on climate may be interactive.

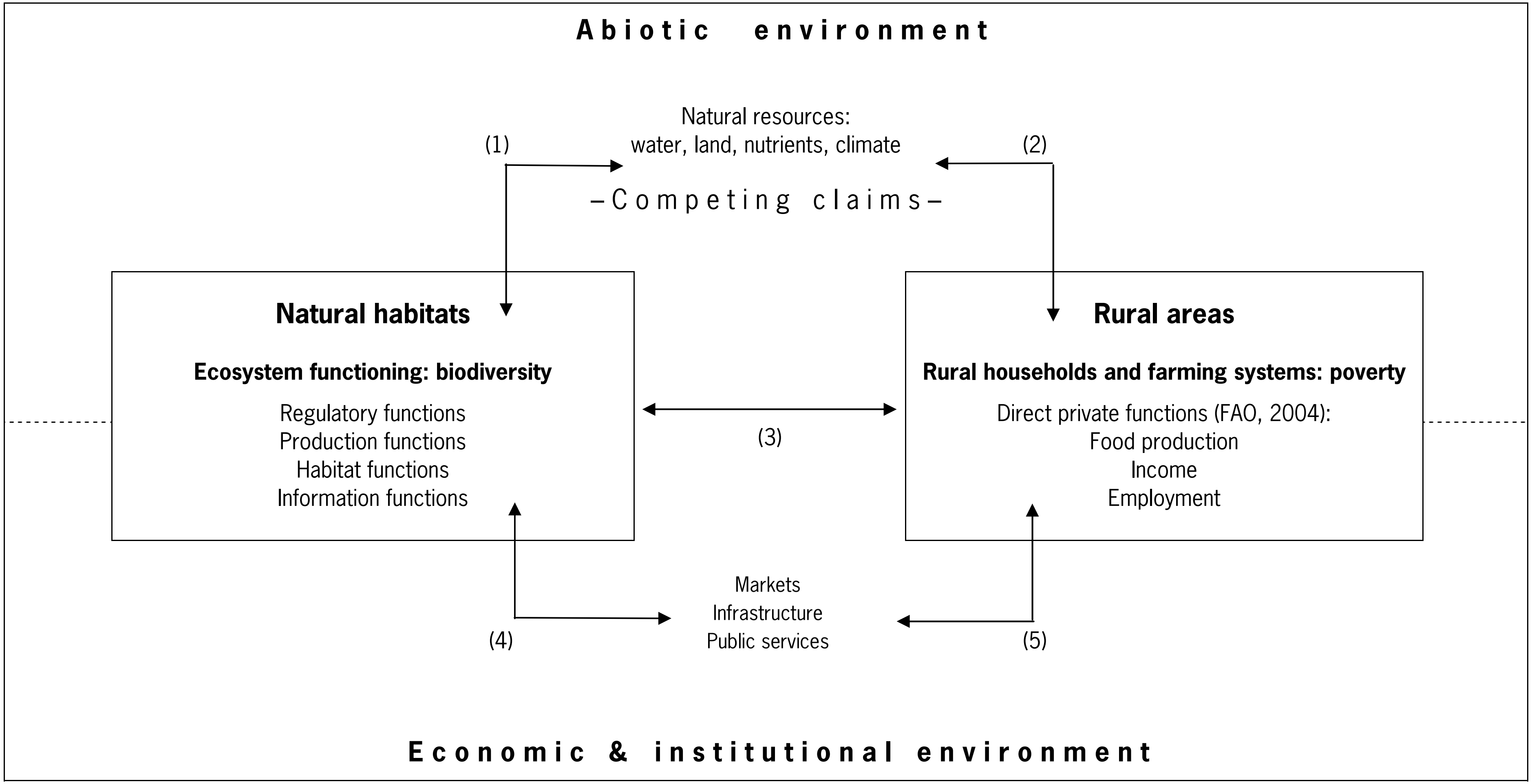


Figure 1. *Relationship between natural habitats and rural areas and the abiotic and economic and institutional environment in which they function.*

There is a direct link between rural areas and natural habitats **(3)**. Rural households may harvest goods and services directly from natural habitats, such as food (fruits, leaves, and bush meat), medicinal plants, fodder, and cultural goods. These products are often grouped under the term non-timber forest products (NTFPs). A natural habitat that is rich in biodiversity provides more choice in terms of NTFPs. Most NTFPs are labor intensive, require little capital and skills, are openly accessible for extraction and provide poor market and price prospects (Angelsen & Wunder, 2003). NTFPs mainly serve subsistence needs and filling gaps in other income (e.g. food shortfalls before the main harvest), only few provide regular cash income. Therefore, the majority of NTFPs are economically inferior products and have little potential for increasing income of the local poor, nor does harvesting of NFTPs in general harm biodiversity in a significant way. However, recent studies focus attention on the interlinkages between the increase in local bush meat demand in parts of Africa and the decrease in marine and freshwater fish supply (Brashares *et al.*, 2004). They relate spatial and temporal changes in the availability of fish with an increase in bush meat trade and the local decline in the number of mammals. In this case, over-harvesting of bush meat has lead to the local extinction of some mammal species. The nature and intensity of activities that rural households carry out in the natural habitats determine their impact on ecosystem functioning and, thereby, on biodiversity.

The nature and intensity of human activities in rural areas and natural habitats is shaped by the presence or absence of institutions (i.e. rules and regulations), indicated by arrows **(4)** and **(5)**. These institutions can take many different forms, from traditional taboos, common property rules to official laws. In dynamic situations, such as a rapidly increasing population, migration, changing market conditions, or conflict and war, prevailing institutions often fail to cope with the newly created situations (Box 7). Institutions that once warranted sustainable and equitable use of natural resources by the rural populations are not able to cater for the needs of a different population, or are no longer enforced. In many countries, adverse government policies have led to the destruction of substantial areas of tropical forest (Repetto, 1988). By pursuing agricultural goals (such as cattle ranching in Latin America (Repetto & Gillis, 1988), or colonization and development of ‘empty’ territories (such as the Mega Rice project in Kalimantan, Indonesia (Meijerink *et al.*, 2004) or the Rio Guayape Project in Honduras (Utting, 1993), or providing adverse incentives with respect to logging (IIED, 1994), governments have directly or indirectly contributed to the destruction of natural habitats.

Box 7

Policy failures

Policy failure is a persistent phenomenon in many developing countries, although there may be differences in character between different countries. Policy failures include the following:

- Shortage of information on causes and consequences of biodiversity loss and on the extent and location of environmental degradation, sometimes inadequately labeled as ‘ignorance’. This policy failure implies high information costs and may result in inadequate policy implementation. Many agricultural policies have, for example, (unintentionally) led to environmental degradation (Ruben & Meijerink, 1994; Binswanger, 1989).
- Government officials that work in their own interest instead of society’s interest, or governments that are influenced by powerful interest groups. Those who are powerful are often involved in economically important activities as well as in environmentally damaging activities. Most of the poorest countries are in the bottom half of the Corruption Index, and are in greatest need of support in fighting corruption (Transparency International, 2004).
- Obstruction by bureaucracy and red tape. Responsibility for maintaining biodiversity is spread over multiple agencies, institutions and departments, which leads to poor coordination.
- A lack of institutional capacity and expertise, including adequate funding and staffing. This failure of enforcing regulations effectively has resulted in legislation becoming ‘paper tigers’. Most countries have laws protecting natural habitats, but often these laws are not enforced.
- Institutional failure occurring when secure property and user rights and equitable allocation are faulty and rules for tenure over renewable resources such as forests are not clearly defined. This failure has led to natural areas being considered as open access areas.

While the direct link **(3)** between rural areas and natural habitats applies to a small extent, a properly functioning economic and institutional environment in which the interactions between both components are formalized has a much larger impact on poverty and biodiversity. Markets exercise a demand for agricultural commodities, bush meat, timber, various NTFPs such as exotic birds or medicinal sources. These markets often cater for (foreign) urban consumers, and do not provide direct incentives for sustainable use. In principle, well-functioning markets offer strong incentives to conserve rather than to overexploit natural resources (Turner *et al.*, 1994). However, markets rarely function properly (Box 8) and, therefore, they do not offer incentives to sustainable use but rather the economic incentives leading to overexploitation and destruction of natural habitats.

Box 8

Market failures

Market failure includes several issues:

- There is no market for many environmental functions. This means there is no price, or that the price does not reflect the real value of the function.
- Even when a price for an environmental function is determined, it does not automatically imply that this price is actually paid by users of biodiversity functions. Benefits and costs enjoyed or borne by others not directly involved in that activity are labeled 'externalities' in economics. Many environmental functions are externalities.
- Difficulties arise in the case of conflicting use by different parties. In case of conflicting use, should there be compensation and if so, by whom and for how long?

Market failures can be deteriorated or improved by policies. In the case of policy failure, market failures usually increase.

Local rural (poor) communities may be involved in the exploitation but direct benefits are often small while indirect benefits (i.e. environmental externalities) are only quantified in few cases (Angelsen & Wunder, 2003). Large scale exploitation is usually done by outsiders. Large scale and capital intensive logging, for example, is often done by foreign contractors and benefits flow to these parties or to governments handing the concessions (Lohman, 1993; Repetto & Gillis, 1988; IIED, 1994). Large scale exploitation of forests is often associated with the development of infrastructure making the area accessible for poor people from outside the region and attracting opportunists and fortune seekers. This adds pressure on remaining resources and usually increases local poverty.

The economic and institutional environment may also be an instrument to protect natural habitats, by establishing and enforcing rules and regulations that ensure sustainable use of natural resources, or by correcting market failures. Market failures can be corrected by, for example, the introduction of compensatory mechanisms for ecological services. Natural habitats provide services, both to the *on-site* local poor, and *off-site* beneficiaries at regional (e.g. downstream water users), national (e.g. tourism) and global level (climate regulation). Often, such off-site beneficiaries are free-riders meaning that they do not pay for the services they get. Local populations who bear the opportunity costs of not 'developing' natural habitats can be rewarded for preserving these services through the introduction of financial compensatory mechanisms. Important services for compensatory mechanisms are (i) carbon storage, (ii) plant and animal species conservation, (iii) hydrological services, and (iv) tourism. Only when institutions and markets are in place, the benefits of compensatory mechanisms for ecological services may reach the poor.

In general, the proper functioning of the economic and institutional environment is crucial for the joined realization of objectives related to rural development, poverty reduction and the conservation of biodiversity. Wunder (2001) argues that the absence of an economic environment (infrastructure, markets) in remote and marginal areas until now has favored the conservation of biodiversity in such areas. As described above, infrastructure and markets can lead to an influx of outsiders, and uncontrolled overuse of natural resources (logging, mining, etc). But at the same time, the absence of an economic environment has isolated these areas and the local poor from opportunities to generate income (marketing of produce, finding off-farm employment).

5. Integrating biodiversity conservation and poverty reduction goals

Poverty and biodiversity issues are so broad, encompassing both international dimensions as well as location-specificity, that resolution of any competing claim and realization of certain objectives depend on complex interactions of physical, biological, socio-economic and institutional conditions and agreements among stakeholders. Scenario analyses provide a strong means to illustrate possible consequences of contrasting positions and options with respect to the simultaneous reduction of poverty and preservation of biodiversity. For each scenario, consequences of choices can be reasoned and possible trade-offs identified. Insight in the consequences and trade-offs of strategic choices reduces the uncertainty that is inherently associated to choices. The scenarios can be considered as strategic options to reconcile the demands of both biodiversity conservation and poverty reduction. They differ in priorities for poverty reduction and biodiversity conservation, and in required interventions and agricultural production systems to achieve joint objectives. In Chapter 6, we elaborate an array of production systems that could be pursued in the rural areas as associated to input requirement, productivity, biodiversity, claims on land, poverty, and hunger.

The framework presented in Figure 1 is used to identify various scenarios to dovetail objectives of poverty alleviation and biodiversity conservation. Starting point in all scenarios is the claim for land as resource of biodiversity and as resource to alleviate poverty. Linking the scenarios to the poverty reduction strategies as described in Section 2.2 helps us to identify specific research issues in each scenario and to provide guidelines for the identification of policy instruments required to create an 'enabling environment' (Box 9). The scenarios are rather meant to disentangle the different positions in strategic debates on how to simultaneously address poverty and biodiversity and are by no means blueprints for implementation.

Box 9

Overview of different policy instruments creating an enabling environment

- Legislative or administrative instruments ('command and control approach') used to create protected areas.
- Fiscal and price instruments (financial incentives) such as subsidies or taxes.
- Private regulation: government creates the condition for the actions of individuals or groups and promotes direct agreements or negotiations between them – includes tradable permits.
- Social instruments (extension, information, advertisements). These aim to persuade individuals, villages communities, corporations, etc. to behave in a socially acceptable manner.

5.1 Scenario development

Here, four contrasting scenarios are identified to reconcile the demands of poverty reduction and conservation. These scenarios represent four major archetypical positions taken up by various actors in the debate on this issue (Adams *et al.*, 2004; Salafsky & Wollenberg, 2000). In all scenarios poverty reduction and the conservation of biodiversity are aims but have different priorities, which result in the development and implementation of different intervention measures. Consequences of different priorities and intervention measures are discussed in qualitative terms, and possible trade-off indicated. Acceptability of the strategic choices will vary among the different actors. Proposed scenarios are meant to clarify resulting consequences for particular choices and to identify research and policy issues with respect to poverty reduction and biodiversity conservation.

The four scenarios are:
1. Protected area scenario (Figure 2A),
2. Buffer zone scenario (Figure 2B),
3. Integrated sustainable development scenario (Figure 2C), and
4. Exit scenario (Figure 2D).

These scenarios present the extremes of the full spectrum of alternatives that can be imagined. Though the scenarios represent contrasting archetypical positions, in practice some or all scenarios can coincide to a certain extent. Various actors in the poverty – biodiversity conservation debate will adopt different positions. Policy that fails to take into account the possible diverse positions in this debate as characterized by the scenarios risks failure to dovetail goals of poverty reduction and biodiversity conservation, and to set an inappropriate research agenda. Interactions between conservation agencies and those committed to livelihood improvement of local people will be facilitated if they understand their mutual positions. Acknowledging the different starting points of various actors and the way they prioritize goals is essential for identification of common grounds, disparities and trade-offs (Adams *et al.*, 2004). Only then appropriate policies and a research agenda can be formulated that are successful and take into account the distinct objectives of poverty reduction and biodiversity conservation. Although poverty reduction and biodiversity conservation are distinct goals there may be considerable overlap in practice. The scenarios are meant to provide a foothold for stimulating creative thinking on where such overlap may occur and how this can be translated into win-win situations by developing policy instruments and projects, and by identifying research needs. We also indicate which types of policy instruments are likely to be the most effective in each scenario.

The identified research topics specified for each scenario are indicative. Similar topics can be valid for different scenarios. To avoid repetition in research topics, we identified as much as possible specific research topics for each scenario. Therefore, the listed research topics in each scenario do not necessarily mean that they should have priority in the further elaboration of specific scenarios. In Chapter 7, we identify cross-cutting themes for a research agenda.

The four scenarios do not address the issues of policy and market failures that lead to biodiversity loss by other parties than the local rural households, for example, migrants, (foreign) logging companies, large-scale cattle rangers, professional poachers, etc. It may be argued that these are more important as a cause of biodiversity loss. For our scenario analyses, we limit our focus on the direct link between biodiversity and poverty of local (rural) households, while external pressure can be incorporated in future comprehensive analyses, e.g. by setting boundary conditions that limit the windows of opportunities for the local households.

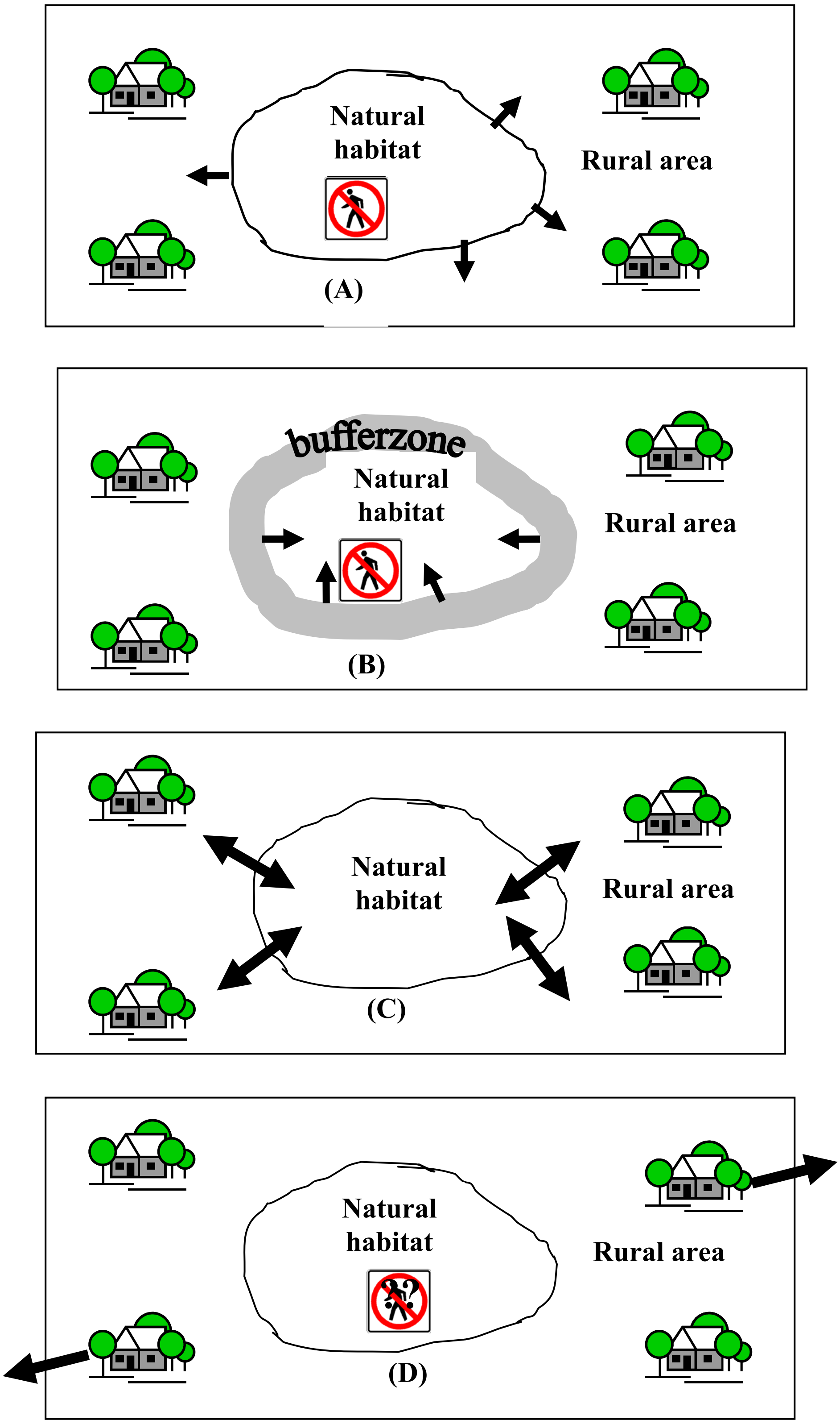


Figure 2. Visual representation of the four scenarios integrating poverty reduction and conservation: protected area scenario (A), Buffer zone scenario (B), Integrated sustainable development scenario (C), and the exit scenario (D).

5.2 Protected area scenario

This position represents the classical approach to protection of biodiversity, also called the 'Yellowstone model' after the USA national park model in which local and indigenous people are excluded from Parks (Schelhas, 2001). Protected areas have strictly defined borders that unauthorized people are not supposed to cross (Figure 2A). Local population is meant to use resources outside the protected area, while plants and animals are supposed to stay within the protected area's borders. In the conceptual framework (Figure 1), this means that the link between rural areas and natural habitats (3) is cut off, while the link between natural habitats and economic and institutional environment (4) changes. On the one hand economic activities are curtailed, on the other hand the institutions protecting the natural habitat are strengthened (rules and regulations pertaining to protected status are enforced).

In this position poverty reduction and conservation are considered distinct sectors of policy formulation. Conservation strategies are enforced with the establishment of protected areas. If conservation goals fail due to poverty, the response is a stronger defense of protected areas, rather than the dissipation of scarce resources in poverty alleviation. Success of conservation is measured in terms of biodiversity criteria, and not in measures of socio-economic development of adjacent living population.

In this view links between natural habitats and rural areas are non-existent, although it is recognized that natural habitats can contribute to livelihoods by providing ecosystem services. Local livelihood is assumed to conflict with conservation resulting in the protected area strategy. Two separate policies should be pursued, i.e., one to conserve and protect the natural habitat, while the other one is aimed at improvement of livelihoods in the neighboring rural area.

Box 10

Controversy over the viability of protected areas

Especially in developing countries the protected park concept has proven difficult to implement (e.g. Rao & Geisler, 1990), although others oppose this view (e.g. Oates, 1999). Latter relate the failure of protected area regimes in Africa in the 1970s and 1980s to economic, social and political problems, often worsened by civil war and corruption (i.e. severe policy failures). As a consequence, financial resources devoted to conservation efforts declined, rural poverty increased, the value of game products increased, thus increasing the destructive pressure on the protected areas. The first view considers these problems structural and argues that protected area strategies are difficult to enforce due to inadequate government resources, weak management capacities and ineffective legal systems in such countries (i.e. policy failures are structural in these countries). Both views have in common that a solid long-term funding and financial management of the protected area, and enabling and enforcing institutions need to be particularly addressed in such a scenario.

Creation of protected areas may require the eviction of land occupiers or right holders in land or other resources which may worsen the livelihood of local people. As the creation of protected habitats causes the foreclosure of future land use options with important opportunity costs, the local poor hardly benefit from this type of conservation. Accompanying activities aimed at development of protected-area tourism in Nepal have shown to provide little benefits to the local poor (Bookbinder *et al.*, 1997).

Other types of accompanying measures are required to reduce poverty of local households in the neighboring rural area. Considering the foreclosure of land use options, land expansion in the adjacent area is no option. Intensification of agriculture, possibly in combination with production diversification, on the remaining farm area is an option. Both strategies require access to credit, supply and product markets, as well as extension services to guide local farmers in the use of external inputs and in the marketing of products. Attention is required for off-site effects of intensive agricultural production on the natural habitat, such as biocide and nitrogen emissions in groundwater or surface water.

Implementation of this scenario requires first of all a policy focus on legislative and administrative instruments. Second, fiscal and price instruments such as subsidies on agricultural inputs may be required for intensification of agriculture outside the borders of the protected area. This may improve access to alternative livelihood strategies to the local poor enabling the escape from poverty without using resources from the protected area. Land that is legally or customarily owned by local people is often difficult to declare off-limits to human needs. Legal and informal land rights should be considered before an area gets a protection status. The size of the protected area should be determined in relation to the specific conservation goal(s) in a given situation. However, it is uncertain whether protected areas are large enough to maintain critical ecological functions over long periods of time. For example, various types of animals need the ability to migrate seasonally or travel between separated populations to avoid extinction (Mac Arthur & Wilson, 1967).

Research and policy issues in this scenario relate to the following:

- Are the required policy instruments such as enabling and enforcing rules and institutions in place? For example, long-term funding arrangements and financial management of the protected area. How to finance costs associated with maintenance of the protected area?
- The quantity and quality of the remaining area/resources of the local population in relation to their basic needs. For example, in semi-arid areas the local population may depend on scarce water resources which after establishment of the protected area may no longer be accessible. What is the production potential of the remaining rural area? Is the local population pushed back in marginal productive areas through the creation of a protected area? In general, do the remaining resources provide sufficient opportunities in relation to the number of people present in the area to escape from poverty?
- The impact of agricultural intensification for the protected area. The issue relates to the direct impact of agriculture, for example nitrogen emissions and erosion, as well as indirect effects such as the danger of encroachment in the protected area when intensification proves to be an effective strategy to reduce poverty.
- To what extent can protected areas sustain critical ecological functions? What is the relation between the size of the area and the population and size of species that can be kept sustainably, such as migrating game?

5.3 Buffer zone scenario

This scenario is based on the protected area scenario but recognizes that poverty in neighboring areas may limit conservation success, or even may cause the failure of conservation efforts. Poverty reduction is instrumental in achieving more effective conservation of biodiversity. This view highlights the competing claims on natural resources and asserts that natural habitats can only be protected if these claims are addressed. In this view conservation can only bear fruit if poverty issues are addressed in a way that pressure on the available natural resource base is reduced. In the conceptual framework (Figure 1) this means that the link between rural areas and natural habitats is not completely cut off, but is limited to a buffer zone area. For the link between economic and institutional environment and natural habitat, the same applies as under the first scenario. Strong institutions (rules and regulations protecting the natural habitat and defining the buffer zone status) need to be in place.

Here, the strategy is to entitle the local population to use biological resources according to well-defined spatial zones (Figure 2B). A core zone is designated as a strict protected area of which the resources are not to be used by local people. Especially, when legal rights of indigenous population are at stake this scenario offers possibilities to respect these rights. As a kind of compensatory measure, part the natural habitat is designated as one or more so-called buffer zones that allow resource use within limits and, hence, to ensure protection of the core zone. These buffer zones enable local people to continue to meet their livelihood needs while key species and habitats are still protected.

The goal of buffer zones is to decrease the reliance on biological resources by substituting other livelihood activities. Substitutive activities should keep local people from livelihood activities that damage local biodiversity, such as the selling of bush meat, logging of forests, etc. Local population may, for example, be assisted in developing farming practices, or off-farm activities. This scenario offers opportunities for introducing financial compensatory measures related to ecological services provided by the buffer zones, such as carbon storage and eco-tourism. Depending on the location-specific context, agricultural development may take the form of land expansion, intensification or diversification of the production portfolio. Compared to the protected area scenario, the buffer zones offer additional land resources to the local population. Hence, expansion of the agricultural area may be an option in certain cases, but not always a feasible solution for the poor (Box 11).

Box 11

Options for poor farm households in East and South East Asia

Rice-based ecosystems in East and South East Asia are being challenged by the simultaneous requirements for more diversified products, increased productivity and reduced environmental impact. In a farm household modeling study consequences of environmental-friendly technological, crop diversification and land expansion options were assessed for poor households in Zhejiang Province of China (Hengsdijk *et al.*, 2004). Results indicated that environmental-friendly technologies (such as site-specific nutrient management) can increase income and rice production of poor farmers and reduce environmental pollution but require access to improved extension services. Diversification of the current rice-based system into vegetables showed that this may increase income of poor farmers, increase income inequalities among rich and poor households and is detrimental to the environment. Expansion of the land holding is not an option for poor farmers as they lack the labor and capital to exploit the additional land resources. Only when the poor have access to credit markets or are able to participate in the off-farm labor markets they are able to benefit from capital-demanding farm activities and from land expansion.

Policy should be prepared that local population is not directly tied to a conservation behavior. As in the previous scenario, poaching and encroachment of the (core) protected zone by local poor remains a problem as people are more likely to incorporate new sources of income as complements to existing activities rather than substitutes for them (Ferraro & Kiss, 2002). In addition, economically attractive activities created in the buffer zone often are incentives for expanding the buffer zones in the protected core area. Controllability of activities is one of the key issues in this scenario. Therefore, as in the first scenario, instruments aimed at command and control should be addressed. In addition, this scenario offers possibilities for stimulating private regulations aimed at tradable permits.

Research and policy issues relate to the following:

- As part of the protected area is sacrificed for the creation of a buffer zone, the issue of the minimum required size of the protected zone in relation to the conservation goal(s) is more critical than in the protected area scenario. At the same time the questions is whether the buffer zone provides sufficient additional resources to sustain local livelihoods.
- Opportunities of different agricultural development strategies to reduce poverty, i.e. land expansion, intensification and production diversification in relation to the resource availability. What strategy is most likely to succeed given the quality and quantity of household’s land, labor and capital assets, and farmer’s goals?
- The three poverty reduction strategies, i.e. land expansion, intensification and production diversification need to be assessed on their possible direct and indirect effects on goods and services provided by the protected area.

5.4 Integrated sustainable development scenario

Within the integrated sustainable development scenario rural communities are encouraged to conserve biodiversity by helping the local population to use it in a sustainable way. Here, the position holds that poor people depend on biodiverse ecosystems, and that their livelihoods only can be improved through appropriate conservation activities. Therefore, conservation is instrumental in achieving poverty reduction. This position might lead to the rejection of the protected area scenario as indicated in Figure 2C by two-sided arrows crossing the border of the natural habitat. The local population is given opportunities to benefit directly from the resources that natural habitats offer. Underlying assumption is that rural households may have a direct incentive to maintain the flow of goods and services from the natural habitats and in this way maintain biodiversity. In the conceptual framework (Figure 1) the link between natural habitats and rural areas (3) is strengthened, and provides the local people resources that sustain their livelihoods. The link between natural habitats and economic and institutions environment (4) should provide rules that protects local rights to local natural resources and land.

In this scenario, local livelihoods drive conservation, rather than the reverse or simply are compatible with it. Local communities may be supported in setting up a NTFP enterprise or an eco-tourism enterprise. Policies may also include the promotion of common-pool resources (fisheries, wildlife and grazing) within the constraints of ecological sustainability. Good governance in this scenario is crucial to ensure that funds for stimulating such developments reach the poor and do not flow into the pockets of local and national political leaders and consultancies (Oates, 1999). Here, sustainable harvesting strategies of natural resources is considered the primary goal to reduce poverty and outcomes of such strategies may deviate to a greater or lesser degree from biodiversity conservation targets. This view considers the linkages between natural habitats and rural areas important for local livelihoods. In this view the goods and benefits produced by natural areas are a means towards poverty reduction. This scenario also offers ample opportunities for the introduction of financial compensatory measures related to ecological services, such as carbon storage, water management and eco-tourism.

This scenario is closely associated with the concept of eco-agriculture which comprises land use systems managed for both agricultural and biodiversity conservation (McNeely & Sherr, 2001). Eco-agriculture is based on the principle of producing more food on less land, which reduces the pressure on the natural habitat. Increase of food production on land with the highest production potential is an important approach to achieve this goal. Eco-agriculture is further based on a combination of different components such as reducing off-site effects of agricultural production (e.g. through the introduction of buffer strips), incorporation of landscape elements on-farm (e.g. using hedgerows), modification of farm management to improve habitat quality, and mixed and diversified farming activities at landscape scale (Box 12). Subsidies and rewarding mechanisms, for example, aimed at the creation and maintenance of landscape elements is required to provide incentives for the adoption of eco-agricultural principles. Also social instruments need to receive attention in this scenario to convince and persuade local populations to practice sustainable harvesting techniques.

Box 12

Effects of agri-environmental schemes in the Netherlands

About 20% of the European Union's agricultural area is under some form of agri-environmental scheme to counteract the impacts of modern agriculture on the environment. These schemes cover a wide range of measures depending on aim and region but have in common that farmers are paid to modify management of (parts of) their farm to benefit biodiversity, environment and landscape. Kleijn *et al.* (2001) looked at the impact of these agri-environmental protection schemes for protection of biodiversity in intensively managed agricultural landscapes in the Netherlands. Fields managed according to the schemes included either postponement of agricultural activities (e.g. mowing of grassland allowing birds safely hatch their eggs), or restrictions in the use of fertilizers (to conserve species-rich vegetation in grasslands). The authors found no positive effect on plant and bird species by comparing 78 paired fields with an agri-environmental scheme and conventionally managed farms.

Research and policy issues relate to the following:

- To what extent does sustainable harvesting of NTFPs and eco-agriculture interfere with or contribute to conservation and poverty goals? On the one hand, overexploitation of precious resources may still pose a threat to natural habitats. On the other hand, do NTFPs and eco-agriculture provide real alternatives to escaping from poverty? Under what type of conditions do eco-agricultural strategies such as mixed cropping and production diversification result in assumed productivity increases, improved income positions of the local poor, and biodiversity conservation? What are critical factors for success of such strategies in terms of biodiversity

conservation and poverty reduction? Do the different components of eco-agriculture, such as the introduction of hedgerows or modification of farm management lead to improvements in biodiversity?
- An important strategy of the concept of eco-agriculture is to intensify the production on most fertile soils, and thus relieve marginal areas. How does this strategy interfere with conservation goals? In other words, when natural habitats are pushed back to the marginal areas, how are conservation goals served?
- What rewarding mechanisms for the construction and maintenance of landscape elements as part of eco-agricultural activities are needed to be economically competitive to other more specialized systems that may, for example, occur in scenario 1 in which nature and agriculture are separated?

5.5 Exit scenario

This scenario is based on empirical evidence that a decreasing rural population reduces human pressure on natural habitats and thus facilitates the recovery and conservation of biodiversity (Figure 2D). The natural habitat is not necessarily a protected area as in the protected area scenario (Section 5.2). Just by reducing the human pressure in the rural area, the adjacent natural habitat may recover or can be more easily preserved. In the conceptual framework (Figure 1) this means that the emphasis is put on the link between rural areas, and the economic and institutional environment (5) so that the links between the rural areas and natural habitats (3) and abiotic environment (2) become less intensive.

This scenario should not be confounded with the removal of indigenous people or their restriction from tribal land in order to establish national parks or other restricted areas. Displacement and mistreatment of Native Americans have been criticized and related to social and ecological biases in American society (Schelhas, 2001). The exit scenario is based on the largely autonomous and global process of rural-urban migration proceeding. In Asia, for example, this process is associated with a strong decline in poverty as urban wages are more remunerative than wages earned in agriculture (Rozelle *et al.*, 2002). Also, rural-rural migration can be part of this scenario as long as local population settles down in rural areas with less competition between agriculture and biodiversity resources (Box 13).

Box 13

Globalization, migration and ecosystems

Floods in Latin America have been associated with deforestation of hill sides (Aide & Grau, 2004). Sixty years ago, most of the mountains in Puerto Rico were also treeless. But forest recovered as the economy shifted from agriculture to industry and services under the influence of socioeconomic globalization. In the fertile lowlands of Puerto Rico, small farms were converted into large-scale and intensive agricultural enterprises. On the one hand, this resulted in a decrease of agricultural labor demand and increased rural-urban migration. On the other hand, it decreased local prices of agricultural products and indirectly influenced land use practices in other parts of Puerto Rico. Especially, farmers on marginal grazing and arable land in the mountains could not compete with the more efficiently producing farms in the lowlands and abandoned their land. Abandonment of these agricultural lands has resulted in an increase of forest cover from <10% to >60% during the last 60 years. Consequently, rain storms hitting the Caribbean May 2004 and causing devastating flooding in Haiti and parts of the Dominican Republic hardly affected neighboring Puerto Rico.

This scenario has links with the main concept of ecoagriculture as described in the integrated sustainable development scenario (Section 5.4), namely the increase of food production on the most fertile land to relieve the pressure on marginal land. This exit scenario differs in the sense that it intentionally aims at migration of the local population from adjacent natural habitats and at production increase in areas with a lower priority for biodiversity conservation. The remaining population in marginal areas could be involved in maintenance of ecological services. Introduction of financial compensatory measures related to ecological services are a prerequisite in this scenario.

This scenario hinges on the creation of employment and wage earning opportunities for migrating population elsewhere in agriculture, or in other sectors. Social safety nets for migrating population in urban areas may be required to avoid a temporary increase in poverty.

Although drivers of migration are diverse and to a certain extent autonomous and difficult to influence, migration can also be stimulated by policy interventions as shown in the case of the Wolong Nature Reserve of China (Liu *et al.*, 2003b). In this panda reserve, the government provides local residents with economic incentives and improved education. Improvement of the education quality increased the chances of local young people to find employment and to pass entrance exams to college and universities elsewhere. Therefore, this scenario is closely associated with fiscal instruments to stimulate migration and with social instruments aimed at improving the capacity of the local population and thus increasing the opportunity to improve their livelihood elsewhere.

Research and policy questions relate to the following:

- Does the available resource base at national scale allow the production of sufficient food and other agricultural commodities to meet the consumptive demand of a growing urban population? Is a smaller agricultural labor force able to sustain a high production level of food and other agricultural commodities?
- Are sufficient employment opportunities available in agriculture or other sectors of society elsewhere for the migrating population? In fact, this issue does not only relate to employment but also to requirements for urban (or rural) housing, home services (such as energy, water and waste disposal), etc. to accommodate migrants.
- Urbanization tends to go at the expense of the most fertile soils (Imhoff *et al.*, 2004) and may result in concentration of pollutants affecting aquatic and coastal marine systems. How do such developments conflict with the goal of biodiversity conservation and shifting agricultural production to the most productive soils?

6. Utilization of rural area

In the previous Chapter four scenarios on possible interactions between natural habitats and rural areas were elaborated. The scenarios differ in the way they assign priorities to poverty alleviation and biodiversity conservation, and thus in the required interventions and agricultural production systems to achieve objectives. Rural areas have a major function in providing food, income, water and other services to local population. The way in which rural areas are used and thus provide livelihoods to rural people has direct and indirect effects on natural habitats.

The evidence is overwhelming that it is essential to accelerate agricultural growth if poverty is to decline rapidly. Agricultural development provides an effective means for both reducing poverty and accelerating economic growth. This is achieved not only by increasing incomes for producers and farm workers but also by creating demand for non-tradable goods- namely services and local products. It is this indirect effect on demand, and the associated employment creation through the off-farm sector of rural areas and market towns that can make a major contribution to the reduction of rural poverty.

In this Chapter we explore the complex relationships between agriculture, poverty and hunger of the rural population with an emphasis on farm households in developing countries. Rural poverty is concentrated in many areas with the richest and most endangered biodiversity. Thus, the relationship between agricultural production systems and biodiversity is also evaluated.

6.1 Linking agriculture to farm household poverty

Here, we introduce a set of concepts to explore the links between agricultural production, poverty and hunger. We take two different approaches for describing agricultural systems as a basis, based on the Farming System Approach by Dixon *et al.* (2001) and the approach based on production ecological principles (Lövenstein *et al.*, 1995; Van Ittersum & Rabbinge, 1997).

The Farming System Approach (FSA) is centered around the activities of farm holdings and incorporates the structural complexity and interrelationships between various components of farm holdings. This approach also shows the variety of natural resources available to farm households such as different types of land, water resources and access to common property resources including ponds, grazing areas and forests. As such it closely relates to the livelihood concept and the basket of assets pertaining to a household (Chapter 2).

Due to our specific emphasis on the natural resource base as a major asset to poor farmers for their livelihood, we further reduce the scope of our framework to agricultural production systems for linking poverty to biodiversity. Agricultural production systems can be effectively described by a production ecological approach as related to crop and animal production *per se*. This approach can be used to evaluate the effects of production technologies with respect to ecological, economic or agricultural objectives at the hierarchical levels of crops, farms and regions. External inputs such as fertilizers are used to manipulate the crop in order to reach high productivity per unit of area. Agricultural activity results in desirable outputs, such as grain or potatoes, and in undesirable outputs, such as nutrient emissions. Thus, agricultural systems can be characterized by their inputs and outputs, i.e., input-output combinations. This approach has a generic applicability and has been applied to analyze other aspects of land use also, such as land quality indicators (Bindraban *et al.*, 2000), world food production (WRR, 1995), and the regional allocation of production and natural areas (WRR, 1992).

The production ecological approach distinguishes three basic production situations. These basic situations are schematically presented in Figure 3 and relevant details are described in Box 14.

Box 14

Production situations

In order of decreasing yields, three production situations can be identified:

Production system 1 - potential yield as described by CO_2, radiation and temperature
The crop is amply supplied with water and nutrients and is free of weeds, pests and diseases. Its growth rate depends only on the current state of the crop and the current radiation and temperature conditions. At full cover, the growth rate of field crops is typically between 150 and 350 kg dry matter ha^{-1} d^{-1}, which is defined as the potential growth rate and the associated yield as potential yield. These growth conditions are realized under intensive field crop and grassland management and often in glasshouses. Crop yields are influenced indirectly by breeding and management tactics.

Production situation 2a – attainable yields as limited by water
The growth rate may be limited by water shortage for at least part of the growing season. This situation is typical for arid and semi-arid regions, but also may occur in other regions under intensive cropping, especially on sandy soils during the drier summer months.

Production situation 2b – attainable yields as limited by nutrients
The growth rate of the crop may be limited by nitrogen shortage for at least part of the growing season and by water shortage. This situation is common in extensive agricultural systems all over the world. Crop growth may be limited by low supply of phosphate and other mineral nutrients in the soil for at least part of the growing season and by water shortage for another part. This situation usually occurs in extensive systems on relatively old soils.

In production situation 2 yield-increasing measures are related to non-substitutable (primary) inputs.

Production situation 3 – actual yields as reduced by effects of weeds, pests, diseases and pollutants
Occurrence of diseases, insect pests, weeds and pollutants (e.g. SO_2 emissions by industries) in any of the preceding productions situations reduces attained yields to the actual level. This is the common situation in the majority of the agricultural production systems in the world, in particular in many developing countries.
Actual supplies of water and nutrients, and yield-protecting measures are related to substitutable (secondary) inputs.

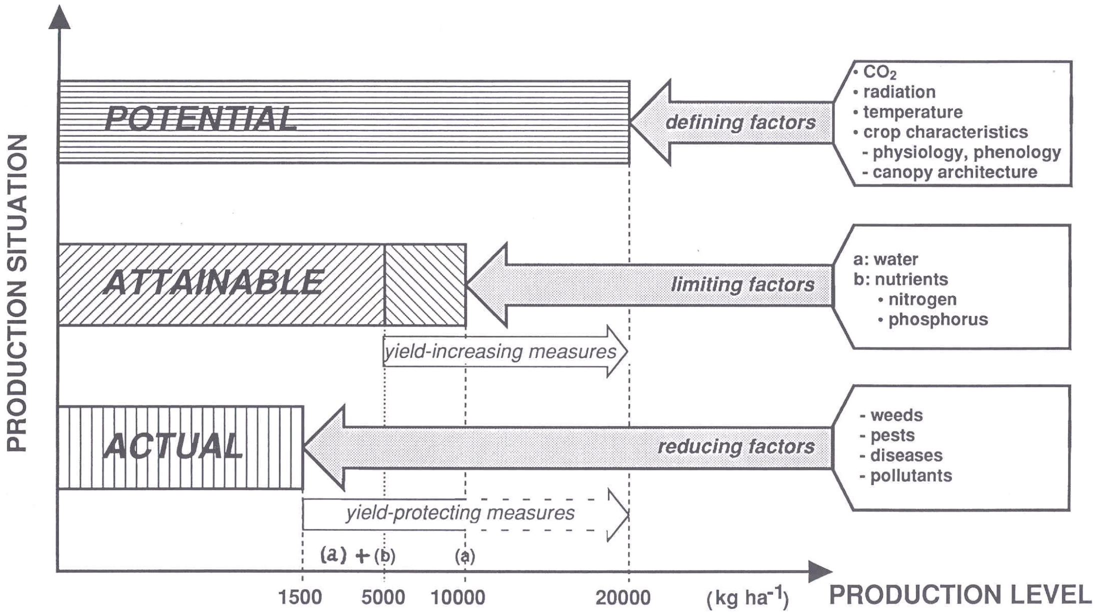


Figure 3. Schematic overview of production situations with corresponding yield level.

We use the approach of production ecology as a theoretical framework to explore the links between agriculture, poverty, hunger and biodiversity. We classify agricultural production systems and describe them in relation to poverty and biodiversity. Subsequently, this classification will be used to identify appropriate strategies to alleviate poverty of farm households.

Although it is recognized that numerous agricultural production systems are practiced, the three basic production situations reflect the major strategies to increase crop yields and also reflect the agricultural development in industrialized countries. Following the logic of increasing intensity in production systems, i.e. an increasing control over the natural biophysical conditions for production, we have identified a total of 12 existing production systems (Table 1), which cover the complete range of the three agricultural production situations as presented in Box 14 and in Figure 3.

One side of the spectrum comprises 'gathering', which is a system of collecting food and non-food items with the least interference in the natural system. The other side is 'conventional European agriculture' in which the control over the biophysical environment is extremely high. Whereas the total output by gathering is minimal in terms of productivity, the diversity of produce may be high. Due to the high specialization, European agriculture is highly productive in terms of food supply, but with a minimal diversity in produce. Each system with its specific input-output relation affects poverty and biodiversity in a different manner. In this report these input-output relations and the implications on poverty and biodiversity have been assessed by expert judgment, and need to be further developed in the future. The 12 production systems provide a comprehensive set that cover the major production systems worldwide.

Table 1. Poverty and hunger of farm households, and aspects of biodiversity for various agricultural production systems.

Agricultural production system[1]	Characteristics (incl. example)	Yield level (grain equivalents; t/ha)[2]	Inputs	Claim on land	Poverty of farm households	Hunger of farm households	Biodiversity (index)	Strategy for poverty alleviation
Gathering (terrestrial)	1. Self-sufficiency (e.g. Amazon-Indians)	0.01	No external inputs of non-renewable fossil energy resources for fertilizers, pesticides and irrigation	Gathering areas	Poverty is high	Quantity, quality and diversity of food supply depends on local conditions and is sufficient for household consumption	Gathering does not affect biodiversity (index = 100)	Exit
Gathering (terrestrial)	2. Economic activity (e.g. bushmeat in West Africa)	0.01	No external inputs of non-renewable fossil energy resources for fertilizers, pesticides and irrigation	Gathering areas	Poverty is high No financial security.	Insufficient security Insufficient quality Insufficient diversity	Loss of biodiversity at genetic and indigenous species level, i.e. extinction of species (index = 75-100)	Off-farm employment Exit
Nomadic	Sudan-Sahel region	0.02	No external inputs of non-renewable fossil energy resources for fertilizers, pesticides and irrigation	Grazing lands	Poverty is high	Insufficient security Insufficient quality Insufficient diversity	The nomadic system does not affect biodiversity as long as stocking density does not exceed carrying capacity (index = 75-100) NB. Cattle owned by urban-dwellers disturbs original system	Expansion Exit

Table 1. (continued)

Agricultural production system[1]	Characteristics (incl. example)	Yield level (grain equivalents; t/ha)[2]	Inputs	Claim on land	Poverty of farm households	Hunger of farm households	Biodiversity (index)	Strategy for poverty alleviation
Shifting cultivation		1	No external inputs of non-renewable fossil energy resources for fertilizers, pesticides and irrigation. Nutrients become available by biomass burning (recycling) Fallow for restoring nutrient balance Rainfed systems Manual and animal labour	Production land Fallow land (3-10* production land)	Poverty is high	Insufficient security High quality of produce High diversity	Loss of biodiversity at genetic, indigenous species and ecosystem (landscape) level. (index = 75-100) Extinction of species occurs especially in tropical forests by habitat loss, habitat degradation and fragmentation Highly diverse systems are converted into much simpler production systems thereby reducing ecosystem diversity	Intensification Expansion Off-farm employement Exit
Diversified agriculture (African type)	Cereal-root crop mixed Maize mixed Agriculture also is an economic activity	1-2	Improved varieties Animal and green manure No mineral fertilizers and biocides Manual labour Water harvesting	Production land Fallow land Land for nutrient accumulation	Medium poverty	Insufficient security Low quality of produce High diversity	Index = 50-75	Intensification Diversification Off-farm

Table 1. (continued)

Agricultural production system[1]	Characteristics (incl. example)	Yield level (grain equivalents; t/ha)[2]	Inputs	Claim on land	Poverty of farm households	Hunger of farm households	Biodiversity (index)	Strategy for poverty alleviation
Organic agriculture (poor soils)	Low input production in African agriculture with animals	1-2	Improved varieties Animal and green manure No mineral fertilizers and biocides Hand labour Water harvesting	Production land Land for nutrient accumulation (10*productive area)	Medium poverty	Insufficient security Low quality of produce High diversity	Index = 25-50	Intensification
Organic agriculture (rich soils)	Organic agriculture Netherlands	3-5	Local varieties 0 kg mineral N/ha Organic manure Bio-pesticides Hand labor and machines	Production land Land for nutrient accumulation (3*productive area)	Low poverty	Low yields per unit area High quality High diversity	Index = 25-50	Intensification (also more mechanization)
Large scale extensive US/Australian agriculture	'Grain belt'	2-6	Improved varieties 75-150 kg mineral N/ha Chemical biocides Machines Irrigation	Production land Polluted areas (erosion)	Low poverty	High quantity High quality	Index = 20	Intensification Expansion Exit

Table 1. (continued)

Agricultural production system[1]	Characteristics (incl. example)	Yield level (grain equivalents; t/ha)[2]	Inputs	Claim on land	Poverty of farm households	Hunger of farm households	Biodiversity (index)	Strategy for poverty alleviation
Irrigated rice cultivation	Asian rice cultivation	3-8	Improved varieties	Production land	Variable poverty	High quantity	Index = 25	Intensification
			125-250 kg mineral N/ha	Polluted areas (salinization)		Low diversity		Diversification
			Chemical biocides					Off-farm employment
			Hand and animal labor, machines					Exit
Integrated European Agriculture	E.g. de Marke (NL)	5-10	Improved varieties	Production land	Low poverty	High quantity	Index = 25	Expansion
			125-250 kg mineral N/ha	Polluted areas (minimal)		High quality		Diversification
			Chemical biocides					Off-farm employment
			Hand labor and machines					Exit
Conventional European Agriculture	North European cereal production	5-10	Improved varieties	Production land	Low poverty	High quantity	Index = 10	Expansion
			250-500 kg mineral N/ha	Polluted areas (loss of productivity)		High quality		Diversification
			Chemical biocides					Off-farm employment
			Machines					Exit

Table 1. (continued)

Agricultural production system[1]	Characteristics (incl. example)	Yield level (grain equivalents; t/ha)[2]	Inputs	Claim on land	Poverty of farm households	Hunger of farm households	Biodiversity (index)	Strategy for poverty alleviation
Intensive livestock	SE Brabant (NL)		Housing Energy for climate regulation	Land for nutrient accumulation Land for production of feed Polluted areas (loss of productivity)	Low poverty	High quantity Sufficient quality	Index = 15 N contamination of soils, water and air Global climate change by methane emissions Animal health issues	Expansion Off-farm employment Exit

[1] *The order of the presented production systems is from actual to potential yield levels (see Box 14).*
[2] *Based on current global cereal production level, on an annual basis (long-term average).*

7. Discussion

7.1 Framework: Assessment of the poverty and biodiversity relationship

Our framework described in Chapter 4 provides a simple and transparent way of linking activities in rural areas and natural habitats, and is a starting point for identifying scenarios which have been elaborated in Chapter 5. There is little evidence to assume that local poor households contribute in a significant way to the widespread destruction of natural habitats and biodiversity. Much more important in natural habitat overuse and destruction are policy failures (adverse policy incentives that promote overuse rather than conservation) and market failures (in which economic incentives make it more profitable to overexploit natural resources rather than sustainable use). These are at the basis of overexploitation by large farmers, migrants, (foreign) timber companies, national governments, etc. At the same time, biodiversity does not seem to provide a viable basis for reducing poverty as long as market failures are not addressed properly (see also Section 7.2.2). Most biodiversity resources may provide important 'safety nets' for local poor, but from a development point of view they are rather 'poverty traps' (Wunder, 2001).

The stylized but coherent set of scenarios as described in Chapter 5 helps us to illustrate some of the consequences of choices and trade-offs involved in reducing poverty and conserving biodiversity. Not all scenarios are suitable for achieving each type of conservation goal. Likewise, not every scenario enables the reduction of poverty to the same extent. Location-specific conditions determine which scenario is most appropriate. Here, the scenarios are used to illustrate the different positions in the debate, which guide us in the identification of relevant policy and research issues.

The production of agriculture-related goods and services can be characterized by various forms of production systems that range from gathering with no control over natural conditions to intensive systems that strongly shape the natural environment. Both types of production systems affect biodiversity and poverty differently, and any assessment of production systems should take into account these differences explicitly. In order to reduce poverty various strategies can be pursued by local poor in utilizing both the natural habitat and the rural areas, following the strategies identified in Section 2.2. The relevancy of strategies in each scenario has been summarized in Table 2, while the strategies apply also to shifts from one production system to the other.

Table 2 Overview of most appropriate poverty reduction strategies in the presented scenarios. Numbers of the strategies refer to those used in Section 2.2.

Protected area scenario	Buffer zone scenario	Integrated sustainable development scenario	Exit scenario
1. Intensification 5. Exit from agriculture	1. Intensification 2. Diversification 3. Expansion of land holding 4. Increase of off-farm income	1. Intensification 2. Diversification 3. Expansion of land holding	1. Intensification 4. Increase of off-farm income 5. Exit from agriculture

Implementation of the poverty reduction strategies may be different in each scenario. For example, intensification of agriculture as in the 'Exit scenario' is supposed to occur far away from the natural habitat in (agriculturally) more favorable areas. In contrast, intensification in the 'Protected area scenario' may occur near the borders of the protected area. Likewise, diversification in the 'buffer zone' and 'Integrated sustainable development' scenarios need to be elaborated in a different way. In the 'Buffer zone' scenario, it refers to diversification of the production portfolio of smallholders and in the 'Integrated sustainable development' scenario to diversification of the landscape by introduction of, for example, shade trees in coffee plantations.

In all scenarios, intensification is an important option to be addressed. This is logical against the background of the food and other agricultural commodities that need to be produced for a growing population with higher living standards (Chapter 1). Spatial claims for biodiversity conservation, thus reducing the area available for agricultural production only increases the needs to intensify agricultural production on the remaining area. Key issue is to what extent each of the poverty reduction strategies contributes to a reduction in poverty taking into account biodiversity goals. For example, intensification is often associated with erosion, pollution of soil, water and atmosphere, and soil salinization. However, many of these undesired effects are a consequence of mismanagement, i.e. over-use of inputs rather than per se the greater use of external inputs per unit of area or per animal. In general, production resources are used more efficiently with increasing yields due to the further optimizing of growing conditions (De Wit, 1992). In other words, the demand for most inputs, expressed per unit of area, increases with increasing yields, but decreases when expressed per unit of product. Hence, in terms of resource use efficiency intensification does not need to conflict with biodiversity goals. Another issue is whether intensification of production does reduce poverty, i.e. is it within reach of poor rural dwellers? Poor farmers are characterized by the lack of capital, while intensification requires capital for purchasing external inputs, such as fertilizers, biocides and improved seeds, etc. In addition, intensification often requires more labor which can not always be provided by poor farm households. Both observations illustrate some of the diverse issues that are at stake while considering the option of intensification. For assessing the consequences of other poverty reduction strategies similar issues are true (see also Box 11). Only an integrated quantitative analysis, taking into account social, economic, biological and physical information on the system under consideration may contribute to a better understanding and *ex-ante* assessment of poverty reduction strategies (Section 7.2.3).

7.2 Cross-cutting policy and research issues

Though several of the specified research and policy topics are scenario-specific, we have identified three cross-cutting issues which have an overall relevance while analyzing the relationships between poverty and biodiversity. These should get priority in the formulation of a (case-specific) research agenda:

7.2.1 Biodiversity indicators

The first issue is of relevance for both other research and policy issues as well and concerns the identification of a (set of) biodiversity indicator(s) that is relevant for policy makers, is analytically sound and measurable, and facilitates unbiased interpretation. In Chapter 2 and 3, we describe how both poverty and biodiversity are measured and characterized in the current public debate. For characterization of poverty the income level and human development index are widely accepted standards for policy formulation (Section 2.1). For characterization of biodiversity such unifying concepts are still lacking which hinders, for example, the achievement of the 2010 biodiversity goals and targets as set by the CBD (Box 5). Question is whether the aim should be the development of a set of individual indicators or a composite indicator as used for measuring poverty. Composite indicators may facilitate comparison of the biodiversity status among ecosystems, but may not be able to capture and measure the achievement of ecosystem-specific conservation goals. In addition, occurring trade-offs among conservation goals are probably difficult to identify using composite indicators. Otherwise, development of a comprehensive set of indicators facilitating the measurement of different goals simultaneously may be costly and difficult to realize because of data requirements. Hence, at different levels, trade-offs are involved which need to be made explicit so that well-informed decisions can be made concerning selection of the most appropriate type of indicator.

From our perspective, the way in which rural areas use natural resources (abiotic environment) is critical to the conservation of natural habitats. In addition to indicators that assess ‘natural’ biodiversity, we urge the need for developing resource use efficiency indicators that can be associated to agricultural activities. Eaton and colleagues (in prep.) stress the need to incorporate production characteristics, such as area for agriculture and the production attained per unit area. In addition, we recommend incorporating additional characteristics such as soil organic matter content, which may reflect the intensity of soil microbes and other organisms, such as earthworms, that functionally contribute to the productivity of the agricultural systems. Tonneijck and colleagues (2005) are currently developing a set of indicators to assess the environmental and resource impacts of organic farming relative to conventional farming systems. Among the impacts are effects on productivity and on biodiversity of terrestrial and soil ecosystems.

7.2.2 Payment mechanisms for environmental services

One of the main issues in conserving biodiversity is that those who benefit from natural habitats do not pay for the costs of maintaining ecosystems functions. Benefits are of a (principally) public good nature, while the costs are borne by the local – often poor- population that live near the natural habitats. Correcting this market failure entails a payment or compensation mechanism that would allow the beneficiaries of functions of natural habitats to pay those who pay the costs of conserving natural habitats. Creation of a market that enables those payments is one possibility. Several initiatives have been developed for such payment schemes. One mechanism is the FSC – Forest Sustainability Certificate, which in effect creates a market for timber that has been harvested in a sustainable way, i.e. by conserving the forest. Another example is the creation of a carbon credit market, in which contributors to the increase of global warming can pay for conservation of tropical forests, which include payments to communities that are involved in conservation efforts (Box 15).

Box 15

The Clean Development Mechanism to conserve natural habitats

As a first step towards reduction of greenhouse gas emissions to the atmosphere, the Kyoto Protocol outlines three types of market-based mechanisms: emission trading, Joint Implementation (JI) and the Clean Development Mechanism (CDM). CDM mechanism provides developing countries with an additional source of income through an environmental service: carbon management. In general, demand for CO_2 reduction comes from industrialized countries that under the Kyoto Protocol need to reduce their greenhouse gas emissions. Besides these parties, several private corporations (mainly fossil fuel and electricity corporations) are initiating projects to offset their own carbon emissions, out of corporate green image considerations or expectation that in the future CO_2 reductions will become stricter. Suppliers of CO_2 reduction are very diverse, ranging from large multinational energy companies to small local operators.
The CDM can be applied to (community) forestry projects and potentially contribute to local livelihoods and ecosystem restoration as well. Costs of such a project consist of the costs involved in CO_2 sequestration itself (forest management) and costs involved in CDM management (also called transaction costs). For a project to be successful, several criteria have to be met concerning the national and regional institutional setting. Some of these criteria are:

- Maximize project success through strong local participation
- Select the most suitable compensation mechanisms
- Enhance the profitability of new land uses
- Increase transparency in investor-community partnerships
- Reduce project marketing costs and investor risks
- Increase scale and reduce costs of community-based CDM projects

The institutional requirements at national level are partially described in the Kyoto Protocol and include the establishment of a national CDM Authority (Smith & Scherr, 2002).

Tropical developing countries can offer low cost carbon offset opportunities. Based on Brown (1997) and WCFSD (1997), Totten (1999) estimates that some 700 million hectares of land in developing countries and countries in transition might be economically attractive for forest carbon programs, resulting in 60 to 87 billion tons of carbon cumulatively conserved and sequestered by 2050, equivalent to 11-15% of the fossil fuel emission over that period. However, if factors such as land tenure, institutional capacity, and other (socioeconomic) constraints are taken into account, these figures may be lower. Institutional capacity is often a restricting factor, both at national and local level, as Meijerink *et al.* (2004) showed in a study into possibilities of implementing CDM in Kalimantan, Indonesia.

In this context, the issue is whether such market initiatives do reach the poor. Taking carbon sequestration as an example: On the one hand, do sequestration programs provide a viable basis to alleviate poverty? On the other hand, are the poor competitive carbon sequestration providers? With respect to the last question, transaction costs associated with payments for carbon sequestration are most likely higher when dealing with small and scattered producers operating under heterogeneous biophysical and institutional conditions (FAO, 2002). With respect to the first question, biophysical conditions under which the poor operate, their livelihood strategies and capital requirements for the adoption of sequestration practices all determine whether carbon sequestration programs contribute to poverty reduction. Hence, whether payments for environmental services contribute to a reduction in poverty still has to be investigated.

7.2.3 Integrated methods and models

The complex relationship between biodiversity and poverty calls for the development of integrated models and methods taking into account the social, economic, biological and physical components of a given system. Models should integrate and synthesize information and knowledge from different disciplines to disentangle the complex and interrelated issues at stake. Given the multiple trade-offs involved in decision-making regarding biodiversity conservation and poverty reduction, policy makers face the increasingly complex task of accommodating multiple objectives of different stakeholders with conflicting interests. Models should provide insight into the opportunities to achieve multiple objectives simultaneously. Formulation of scenarios based on different viewpoints about uncertain developments should enable the quantification of trade-offs between biodiversity, poverty and other policy objectives. Considering the different types of research issues and scales involved, we propose a toolbox consisting of different models and methodologies rather than one mega model. Depending on the specific aim and scale of study an appropriate model needs to be selected to improve insight in the relevant relationships and to reduce the uncertainty in our choices related to development. Such a toolbox may contribute to a better understanding of the functioning of ecosystems, projecting possible future developments, exploring of policy options, assessing the possible consequences of intervention methods for different stakeholders, and guiding data collection and future research agendas. Models may be developed to assess, for example, *ex-ante* the consequences of intensification, diversification and land expansion for poor farm household and the environment (Hengsdijk *et al.*, 2004; Box 11). Another type of integrated model application to support informed and balanced decision-making with respect to land and resource management is illustrated in Box 16.

Box 16

Options for the conservation of natural forests in Costa Rica: An example of integrated land use analysis

Natural forests prevail in the northern part of the Atlantic zone in Costa Rica, but deforestation accelerates rapidly after the construction of a major highway in the late 1980s. After the international discussion on global warming at the 1992 Rio Conference on Sustainable Development, the Costa Rican government developed a 'payment for environmental services' instrument to reward owners of natural forests with US\$ 40 ha^{-1} y^{-1} in return for their protection. The payment is about double the amount that can be earned through sustainable wood extraction (Bulte *et al.*, 2000). In an integrated regional land use model effects of this policy instrument were assessed taking into account other land use alternatives, regional resource availability, price elasticity of output products and the labor market (Jansen *et al.*, 2005; Nieuwenhuyse *et al.*, 2000). Hence, information from different disciplines ranging from soil sciences, forestry, agronomy to econometrics was integrated. The analysis showed that current payments are well below the average opportunity costs of forests on land suitable for agricultural production. Opportunity costs of this forest land were estimated at around US\$ 120 ha^{-1} y^{-1} ,which largely was determined by the returns to beef cattle raising on natural pastures. Further model simulations showed that when payments would be raised to 130 US\$ ha^{-1} y^{-1} conversion from pastures back to forests would become attractive for land owners. The study showed that current payment level provides little incentives for conservation of forests on lands with high agricultural potential.

Many of the existing types of integrated models are able to take into account agricultural productivity, economics, and environmental pollution/depletion associated with agricultural production. These environmental issues refer to some of the ecosystems services. However, they do not fully account for the wide range of ecosystems services that may be affected by agricultural practices. This can be explained partly by the lack of knowledge on underlying processes and partly by the conceptual limitations of the used methodologies. Therefore, both improved understanding of ecosystem processes and components is required, and improvements and expansion in methodologies that are able to incorporate and integrate this newly acquired knowledge.

The framework that we have provided comprises three components: I) a description of the relationships between natural habitats and rural areas, II) a scenario approach to explore trade-offs between goods and services in relation to poverty reduction and biodiversity conservation and to identify relevant research issues for each scenario, and III) a set of production systems using natural resources differently and, therefore, affecting biodiversity differentially. This approach can be applied at various scales. It can be used to analyze specific cases of regional development, but it can also be used to explore trade-offs at global scale. The ultimate models and the parameterization will differ though depending on the scale of analysis.

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