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Operationalising sustainability impact assessment of land use scenarios in developing countries: A stakeholder-based approach with case studies in China, India, Indonesia, Kenya, and Tunisia

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Table of contents

Summary

Growing populations, continued economic development, and limited natural resources are critical factors affecting sustainable development. These factors are particularly pertinent in developing countries in which large parts of the population live at a subsistence level and options for sustainable development are limited. Therefore, addressing sustainable land use strategies in such contexts requires that decision makers have access to evidence-based impact assessment tools that can help in policy design and implementation. Ex-ante impact assessment is an emerging field poised at the science-policy interface and is used to assess the potential impacts of policy while also exploring trade-offs between economic, social and environmental sustainability targets.

The objective of this study was to operationalise the impact assessment of land use scenarios in the context of developing countries that are characterised by limited data availability and quality. The Framework for Participatory Impact Assessment (FoPIA) was selected for this study because it allows for the integration of various sustainability dimensions, the handling of complexity, and the incorporation of local stakeholder perceptions. FoPIA, which was originally developed for the European context, was adapted to the conditions of developing countries, and its implementation was demonstrated in five selected case studies.

In each case study, different land use options were assessed, including (i) alternative spatial planning policies aimed at the controlled expansion of rural-urban development in the Yogyakarta region (Indonesia), (ii) the expansion of soil and water conservation measures in the Oum Zessar watershed (Tunisia), (iii) the use of land conversion and the afforestation of agricultural areas to reduce soil erosion in Guyuan district (China), (iv) agricultural intensification and the potential for organic agriculture in Bijapur district (India), and (v) land division and privatisation in Narok district (Kenya).

The FoPIA method was effectively adapted by dividing the assessment into three conceptual steps: (i) scenario development; (ii) specification of the sustainability context; and (iii) scenario impact assessment. A new methodological approach was developed for communicating alternative land use scenarios to local stakeholders and experts and for identifying recommendations for future land use strategies. Stakeholder and expert knowledge was used as the main sources of information for the impact assessment and was complemented by available quantitative data.

Based on the findings from the five case studies, FoPIA was found to be suitable for implementing the impact assessment at case study level while ensuring a high level of transparency. FoPIA supports the identification of causal relationships underlying regional land use problems, facilitates communication among stakeholders and illustrates the effects of alternative decision options with respect to all three dimensions of sustainable development. Overall, FoPIA is an appropriate tool for performing preliminary assessments but cannot replace a comprehensive quantitative impact assessment, and FoPIA should, whenever possible, be accompanied by evidence from monitoring data or analytical tools. When using FoPIA for a policy oriented impact assessment, it is recommended that the process should follow an integrated, complementary approach that combines quantitative models, scenario techniques, and participatory methods.

Zusammenfassung

Bevölkerungswachstum und wirtschaftliche Entwicklung in Kombination mit begrenzt verfügbaren, natürlichen Ressourcen sind kritische Faktoren für eine nachhaltige Entwicklung. Diese Situation ist besonders in Entwicklungsländern anzutreffen, in denen große Teile der Bevölkerung am Existenzminimum leben und es oft wenig Spielraum für eine nachhaltige Entwicklung gibt. Entscheidungsträger fragen daher verstärkt wissenschafts-basierte Instrumente zur Vorab- (ex-ante) Folgenabschätzung (Impact assessment) für die Konzeption und Umsetzung nachhaltiger Strategien nach. So genannte ex-ante Methoden zielen hierbei auf die Beurteilung der zukünftigen Folgen von Szenarien (z.B. alternative Politikmaßnahmen) und Konflikte zwischen ökonomischen, sozialen und ökologischen Nachhaltigkeitszielen ab.

Ziel dieser Arbeit war es, die Folgenabschätzungen von Landnutzungsszenarien auf die nachhaltige Entwicklung in Entwicklungsländern zu ermöglichen. Eine besondere Schwierigkeit stellt dabei die oft mangelhafte Verfügbarkeit von Daten dar, die quantitative Analysen bzw. den Einsatz von computergestützten Modellen meist nur sehr begrenzt möglich macht. Um mit diesen Schwierigkeiten umzugehen, wurde die ursprünglich für die Europäische Union entwickelte ‚Framework for Participatory Impact Assessment' (FoPIA)-Methode an die Bedingungen in Entwicklungsländern angepasst und in fünf regionalen Fallstudien angewendet.

Die analysierten Landnutzungsszenarien umfassten dabei (i) alternative Raumplanungsmaßnahmen zur kontrollierten Stadt-Land-Entwicklung in Yogyakarta, Indonesien; (ii) die Umsetzung von boden- und wasserkonservierenden Maßnahmen zur Verbesserung der landwirtschaftlichen Produktion im Oum Zessar Wassereinzugsgebiet, Tunesien; (iii) Landumwandlung und Aufforstungsmaßnahmen zur Eindämmung von Bodenerosion in Guyuan, China; (iv) landwirtschaftliche Intensivierung und Potenziale des ökologischen Landbaus in Bijapur, Indien; sowie (v) Landteilung und -privatisierung in Narok, Kenia.

Die angepasste FoPIA Methode wurde in drei konzeptionelle Schritte unterteilt: (i) die Szenarienentwicklung, (ii) die Spezifikation des Nachhaltigkeitskontexts, und (iii) die Szenariofolgenabschätzung. Ein neuer methodischer Ansatz lag in der Entwicklung alternativer Landnutzungsszenarien mit regionalen Akteuren und auf der Ableitung von Handlungsempfehlungen für zukünftige Landnutzungsstrategien. Für die Szenario-

folgenabschätzung wurde primär das Wissen regionaler Experten und Akteure genutzt und durch quantitative Daten, sofern verfügbar, ergänzt.

Auf der Grundlage der in den fünf Regionen gewonnenen Erkenntnisse lässt sich schlussfolgern, dass die angepasste FoPIA Methode dazu geeignet ist, eine Szenariofolgenabschätzung zu strukturieren und ein hohes Maß an Transparenz zu gewährleisten. Sie ermöglicht kausale Zusammenhänge von Landnutzungsproblemen zu diagnostizieren, die Kommunikation zwischen unterschiedlichen Akteuren und Experten zu verbessern sowie mögliche Konflikte zwischen ökonomischen, sozialen und ökologischen Nachhaltigkeitszielen zu erkennen und darzustellen. Insgesamt sollte die FoPIA Methode jedoch nicht als isolierte Methode zur Folgenabschätzung verstanden werden, sondern, sofern die Datenverfügbarkeit dies zulässt, durch weiterführende Analysen ergänzt werden. Für die Anwendung der FoPIA Methode im Rahmen der Politikfolgenabschätzung wird ein integrierter, komplementärer Ansatz empfohlen, der quantitative Modelle, Szenariotechniken und partizipative Methoden kombiniert.

Abbreviations

BAU	Business as usual
CAS	Chinese Academy of Sciences
CEC	Commission of the European Communities
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement
DIY	Daerah Istimewa Yogyakarta (Special Region of Yogyakarta)
DPSIR	Driver-pressure-state-impact-response (analytical framework)
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FF	Forest function
FoPIA	Framework for Participatory Impact Assessment
FSSIM	Farming Systems SIMulator
GDP	Gross Domestic Product
GMU	Gadjah Mada University
Ha	Hectares (unit of area defined as 10,000 square metres)
IA	Impact assessment
ICRAF	International Center for Research in Agroforestry
IDRISI	Integrated geographic information system (GIS)
IGSNRR	Institute of Geographic Sciences and Natural Resources Research
ILRI	International Livestock Research Institute
KARI	Kenya Agriculture Research Institute
LEI	Landbouw Economisch Instituut (Agricultural Economics Institute), Wageningen University
LUF	Land Use Function
LUPIS	Land Use Policies and Sustainable Development in Developing Countries (EU FP6 Project)
MCA	Multicriteria analysis
MDGs	Millennium Development Goals
Mu	Chinese unit of area (15 mu = 1 ha)
NGO	Non-governmental organization
RMB	Renminbi (Yuan, currency of China)
SD	Sustainable Development
SEAMLESS	System for Environmental and Agricultural Modelling: Linking European Science and Society (EU FP6 Project)
SENSOR	Sustainability Impact Assessment: Tools for Environmental, Social and Economic Effects of Multifunctional Land Use (EU FP6 Project)
SIA	Sustainability Impact Assessment
SIAT	Sustainability Impact Assessment Tool

SLCP	Sloping Land Conversion Program
SSNM	Site-Specific Nutrient Management
SWC	Soil and Water Conservation
UN	United Nations
UON	University of Nairobi

SLCP   Sloping Land Conversion Program

Chapter 1

General introduction

1.1   Background and motivation

Growing populations, continued economic development, and limited natural resources are considered critical factors for sustainable development. These factors are particularly pertinent in developing countries in which large parts of the population live at a subsistence level and where options for sustainable development are limited. Land use policies that aim to address these problems often fail because they do not sufficiently consider regional characteristics and often neglect the needs and preferences of local stakeholders (e.g., Bennett et al. 2011; Cao 2008). Therefore, sustainable and harmonised strategies for land use are needed; these strategies should stimulate economic development while also promoting social equity and preserving the environment.

1.2   Land use and sustainability

Land use in rural areas has long been dominated by agriculture and forestry; however, society has placed ever increasing demands on land use, and required that such use serve multiple functions and provide varied services (Wiggering et al. 2003). On the global scale, agriculture, including cropland and grassland, is the main economic land use activity, accounting for approximately 40% of global land use area (Foley et al. 2005), followed by forests, which occupy approximately 31% of land on the global level (FAO 2010). Urban areas are often the most intensive land use activity (Lambin et al. 2001) but cover less than 3% of the global terrestrial land surface (Grimm et al. 2008).

In many developing countries land use changes are highly dynamic and often uncontrolled (Lambin et al. 2003). Continued population growth and economic development are considered to be the two main human-related driving forces of land use changes (Foley et al. 2005). Limited and unevenly distributed land resources, poverty and migration often lead to an overexploitation of natural resources and land degradation (Geist and Lambin 2002).

With regard to sustainable development, a crucial aspect in many developing countries is that sustainability concerns are often related to fundamental living standards, including food security and poverty eradication, or social equity (Singh et al. 2009). Where land use is under transition, conflicts are often unavoidable; for example, conflicts can occur between 'traditional herders' (using common land resources) and crop farmers (often private land with restricted access) (e.g., Jeddi and Chaieb 2010; Jun Li et al. 2007; Mwangi 2007). Apart from these regional land use problems, the worldwide loss of rainforests and biodiversity is one example of a global sustainability concern that occurs

primarily in developing countries where the last areas of large natural forests exist (e.g., Brooks et al. 2002; Geist and Lambin 2002).

With the concept of land use functions (LUFs) as first described in Pérez-Soba et al. (2008), an attempt to operationalize sustainable development related to land use was introduced (Helming et al. 2011a). LUFs are defined as 'goods and services' provided by different land uses and summarise the most relevant economic, social and environmental aspects of a region (Pérez-Soba et al. 2008). These include, for example, the provision of land-based products, space for industry and services, infrastructure (mainly economic functions and services), food supply, work, health, cultural identity and heritage (mainly social functions and services), and the provision of abiotic and biotic resources and ecosystem functions (mainly environmental functions and services).

1.3 Impact assessment

Policy makers are increasingly tasked with designing and implementing land use policies towards sustainable development, but they often realise that they do not know enough about the complex interdependencies between human activities and the environment and possible, unknown future developments. Therefore, innovative research methods are needed to support the development of sustainable strategies while harmonising the economic, social, and environmental dimensions of sustainability (Wiggering et al. 2006). Sustainability impact assessment (SIA) is an emerging field in the science-policy interface with the goal of providing evidence-based decision-making support for better governance facilitating sustainable development (George and Kirkpatrick 2006; Kates et al. 2001; Pope et al. 2004).

In general terms, impact assessment can be described as a tool with which to attribute the difference between two conditions to a certain cause, for example, the existence of a policy measure, and to reveal causal relationships between the cause and the impact. Indicators are commonly used in impact assessment to attribute and measure changes for evaluation against defined objectives and targets. Impact assessment can also be described as a procedure of learning and adoption, for example, when decision makers are involved in the assessment process and consider new insights and knowledge about possible policy impacts in their decision-making process (Morris et al. 2011). In the European Union (EU), ex-ante policy impact assessment is a mandatory instrument to assess possible policy impacts before implementation in accordance with the EU guidelines for impact assessment introduced in 2005 (see Commission of the European

Communities (CEC) 2009). These guidelines recommend six analytical steps for ex-ante policy assessment, including (i) the identification of the problem, (ii) the definition of objectives, (iii) the development of the main policy options, (iv) the analysis of the impacts of the options, (v) the comparison of the options, and (vi) outlining policy monitoring and evaluation (Commission of the European Communities (CEC) 2009).

In ex-ante impact assessments, the guiding question is "What would happen if...?". For this purpose, scenarios are a widely used technique, for example, in the field of policy analysis and impact assessment (e.g., Alcamo, 2001; Kok et al. 2006), and can be used to explore and compare alternative options of possible future states (Helming et al. 2011a; Rounsevell and Metzger 2010) or to stimulate debates amongst decision makers (Van Notten et al. 2003). In the field of land use science, several research initiatives have been undertaken to develop a variety of integrated policy impact assessment tools for scenario analysis to promote research-based decision-making support (e.g., Helming et al. 2011a; Petit and Frederiksen 2011; Uthes et al. 2010; Van Ittersum et al. 2008). These tools include a variety of quantitative, mainly computer-based models, and also qualitative and participatory methods (see König et al. 2010). The 'Driver-Pressure-State-Impact-Response' (DPSIR) framework described in Smeets and Weterings (1999) is commonly used to attribute and analyse policy impacts and to assess indicator changes in a structured manner (e.g., Helming et al. 2011a; Nesheim et al. 2012; Tscherning et al. 2012).

Growing evidence suggests that stakeholder participation can enhance decision-making processes (Reed 2008). Therefore, the role of stakeholder participation in impact assessment has increasingly been acknowledged by several studies, for example, to specify a context-specific problem (e.g., Patel et al. 2007; Walter and Stützel 2009), to define causal relationships between human activity and impact (e.g., Sandker et al. 2010; Sheate et al. 2003), to consider local perceptions (e.g., Fraser et al. 2006; Reed 2008; Stringer et al. 2006), to develop regionally sound scenarios (e.g., Fürst et al. 2010; Kok et al. 2006; Sheppard 2005; Tress and Tress 2003), or to integrate multiple dimensions and different views of sustainability (e.g., Castella et al. 2007; De Groot 2006). Stakeholder participation in the development of indicators is not only crucial for selecting regionally relevant indicators but also to improve the recognition and use of indicator results (e.g., Rametsteiner et al. 2011).

1.4   Limitations in impact assessment

Incomplete information is one of the main constraints for decision making, both in developed and in developing countries (Bacic et al. 2006). In the EU, one major objective of impact assessment is to provide transparent information about possible policy effects and trade-offs among social, economic and environmental sustainability dimensions (Helming et al. 2011a; Uthes et al. 2010) with tools that often utilise EU-wide monitoring systems. Although the impact assessment procedures in the EU still have considerable limitations, as was analysed by Renda (2006), they can at least build on a relatively consistent provision of indicators over longer time horizons, which is usually not the case in developing countries. Another challenge refers to the consideration of the economic, social and environmental sustainability dimensions that often lack a balanced integration in sustainability-oriented impact assessments (see Helming et al. 2011a; Schößer et al. 2010; Wiggering et al. 2006). In this regard, quantitative computer tools are often limited in their applications because they do not fully integrate multiple dimensions of sustainability. As a compromise, such tools are often accompanied by more qualitative and participatory methods to consider various perspectives in the SIA.

Impact assessment in developing countries differs from that in the EU. In many cases, monitoring systems are not available or are just being implemented, computational systems are often not standard, and the definition and collection of data are often not harmonised. Lambin et al. (2003) report, for example, that land use statistics in developing countries often considerably underreport agricultural land area. Data are also often irregularly collected, available only in paper-based format and in the national languages, incomplete or obviously manipulated, or may not exist at all. Moreover, access to data can be a question of power and depends on established connections. Usually, no official strategic guidelines exist, and therefore, decision-makers and administration personnel in developing countries are often not familiar with ex-ante impact assessment techniques or with options of how to interpret and approach the concept of sustainability.

1.5   Study context

This study was part of two EU-funded research projects, namely, SENSOR-TTC (Sustainability Impact Assessment: Tools for Environmental, Social and Economic Effects of Multifunctional Land Use in Targeted Third Countries, www.sensor-ip.org) and LUPIS (Land Use Policies and Sustainable Development in Developing Countries, www.lupis.eu). In both projects, several case study regions were targeted in developing

countries in which highly dynamic land use changes have caused regional land use and sustainability problems. For this study, five contrasting project case studies were considered appropriate for conducting impact assessments of alternative land use scenarios, including those with regionally different land use problems and related policy options. In the Yogyakarta region of Indonesia, economic development and high migration rates have caused uncontrolled expansion of settlements, leading to a rapid rural-to-urban land conversion. Spatial planners seek to develop and implement effective measures to reduce negative side effects, such as illegal land clearance and housing and increasing water pollution (see König et al. 2010; Chapter 2). In the arid Oum Zessar watershed of Tunisia, water scarcity is the main limiting factor for land-based production, allowing only for limited types of land use (e.g., keeping drought-resistant animals, planting olive trees, etc.). A range of soil and water conservation measures have been implemented to improve the economic production from agricultural land (see König et al. 2012; Chapter 3). In the district of Guyuan, China, population growth resulted in the expansion of agricultural activities into steep sloping areas (terracing) that are vulnerable to soil erosion. A nationwide land conversion programme has been implemented that aims to convert the terrace farms into grassland and forests (see König et al. 2012; Chapter 4). In the region of Bijapur, India, industrialisation of the agricultural sector has forced thousands of small-scale farmers to the margin of subsistence. Alternative production systems, for example, organic farming, have been promoted by local NGOs to reduce the use of external inputs while making small-scale farmers more independent from competitive market structures (see König et al. under review; Chapter 5). In the district of Narok, Kenya, growing land use conflicts among market-oriented crop farmers, wildlife conservancies, and herders have led to increasing land use conflicts and environmental degradation problems. A land sub-division policy was therefore promoted and partly implemented that aimed at the privatisation of common land (see König et al. *under review*, Chapter 5).

1.6 Study aim and objectives

The main aim of this study is to operationalise sustainability impact assessment of land use scenarios in the context of developing countries. To achieve this aim, while faced with the aforementioned challenges of limited data availability and quality, the need for integration and handling of complexity, and the necessity to include local stakeholder perceptions, the Framework for Participatory Impact Assessment (FoPIA) was selected

for this study. FoPIA was originally developed as part of the SENSOR project by Morris et al. (2011) to complement the development of computer-based SIA tools within the EU context but can also be used as a stand-alone assessment method (Helming et al. 2011b). FoPIA provides a sequence of methods that allows stakeholder-inclusive impact assessments.

The general objective of this thesis is underpinned with three specific sub-objectives:

1. To adapt the FoPIA method for impact assessment in the context of developing countries.

2. To expand the scope of the FoPIA method for conducting comprehensive impact assessment, considering both qualitative and quantitative knowledge in a complementary way.

3. To evaluate the utility of the FoPIA method for application in developing countries.

1.7 Outline of the study

This thesis consists of seven chapters and is based on five research papers (presented here as Chapters 2 to 6), which are all published or under review in international and peer-reviewed journals. Chapter 1 comprises the general introduction and Chapter 7 the general discussion and conclusions. In contrast to the Chapters 1 and 7, the papers presented in the Chapters 2 to 6 are written in first-person plural because they are co-authored. I am the first author of the papers presented in Chapters 2 to 5 and the second author of the paper presented in Chapter 6. Because this thesis is based on a cumulative approach, the contents of some chapters may overlap.

I. The **first paper**, "Assessing the impact of land use policy on urban-rural sustainability using the FoPIA approach in Yogyakarta, Indonesia", describes the application of FoPIA to a developing country for the first time, in this case to the region of Yogyakarta in Indonesia (see Chapter 2). For this purpose, FoPIA was adapted from Morris et al. (2011) and divided into three manageable assessment steps: (i) scenario development, (ii) specification of the sustainability context, and (iii) scenario impact assessment, while following the proposed assessment structure of the integrated assessment framework described in Chapter 6. My contributions to this paper were as follows: original idea, literature review, method adaptation and application, workshop organisation, data collection and analysis, main author (König et al. 2010, published in *Sustainability*).

II. The **second paper**, "Participatory impact assessment of soil and water conservation scenarios in Oum Zessar watershed, Tunisia", presents the results of an impact assessment of alternative policy implementation scenarios of soil and water conservation measures using the adapted FoPIA method in a new context for the case of the Oum Zessar watershed in Tunisia (see Chapter 3). Whereas indicators were largely predefined for the case in Indonesia, the Tunisian case study emphasised the participatory elaboration and acceptance of suitable assessment indicators by stakeholders. My contributions to this paper were as follows: original idea, literature review, method adaptation and application, workshop organisation, data collection and analysis, main author (König et al. 2012, published in *Environmental Management*).

III. The **third paper**, "Assessing the impact of the sloping land conversion programme on rural sustainability in Guyuan, Western China", presents the results of a comprehensive impact assessment (see Chapter 4). For this purpose, FoPIA was used to conduct two complementary impact assessments, one assessing the SLCP impacts on the regional level considering a local stakeholder group and the other assessing alternative forest management options considering an external expert panel. The analysis of the assessment results was complemented by a comprehensive survey and analysis of the scientific literature to derive a robust impact assessment result. My contributions to this paper were as follows: original idea, literature review, method development and application, workshop organisation, data collection and analysis, main author (König et al. 2012, published in *Land Degradation & Development*).

IV. The **fourth paper**, "Regional impact assessment of land use scenarios in developing countries using the FoPIA approach: findings from five case studies", aimed to evaluate the suitability of FoPIA for conducting impact assessment in the context of developing countries by comparing the results of five independent FoPIA applications to different case studies contexts in China, India, Indonesia, Kenya and Tunisia (see Chapter 5). Implications of the regional scenario impacts as well as methodological strengths and shortcomings are discussed. My contributions to this paper were as follows: original idea, literature review, method application, workshop organisation, data collection and analysis, main author (König et al. under review in *Journal of Environmental Management*).

V. The **fifth paper**, "Methods and tools for integrated assessment of land use policies on sustainable development in developing countries", presents an integrated assessment framework that has been developed apart from the FoPIA method (see Chapter 6). This framework can be used to set up and structure an impact assessment and shows how to select and apply different assessment tools, combining quantitative and qualitative approaches in a complementary manner. The adaptation of FoPIA to the context of developing countries benefited from the inclusion of structural elements from the integrated framework; in addition the FoPIA method is proposed as a qualitative impact assessment tool in this framework where complex and data-driven modelling tools fail. An illustrative example of how to use the integrated framework is given for a water pollution case in the Taihu basin in China. My contributions to this joint paper, which was a result of the LUPIS research project, included conceptual contributions to the development of the integrated assessment framework and credit as the second author (Reidsma et al. 2011, published in *Land Use Policy*).

Chapter 2

Assessing the impact of land use policy on urban-rural sustainability using the FoPIA approach in Yogyakarta, Indonesia

Abstract

This paper presents the results of a sustainability impact assessment (SIA) of policy induced land use changes in Yogyakarta, Indonesia. The regional problems include rapid expansions of urban areas, due to high population pressure, and the conversion of paddy fields and forests into settlements. The objective of this study was to assess the impacts of two land use policies on social, economic, and environmental Land Use Functions (LUFs) in Yogyakarta. The following scenarios were developed for the SIA: a forest protection scenario (S1), a paddy field conservation scenario (S2), and a counterfactual (no policy) scenario of 'Business As Usual' (BAU). The Framework for Participatory Impact Assessment (FoPIA) was applied to conduct an expert-based impact assessment. For the specification of the regional sustainability context, a set of nine key LUFs and associated indicators were developed, including three social, three economic, and three environmental sustainability criteria. The resulting scenario impacts of the assessment differed considerably, with positive impacts of the S1 and S2 scenarios on seven of nine LUFs, and negative impacts of the BAU scenario on six LUFs. The perception of the FoPIA method by the regional stakeholders was positive. We conclude that this method contributes toward an enhanced regional understanding of policy effects and sustainability, particularly in data-poor environments.

2.1 Introduction

Sustainability oriented policy making requires a comprehensive and reliable analysis of ex ante impacts of policy changes on the economic, environmental and social components of development (Helming et al. 2008; Pope and Grace 2006; Scrieciu 2007). Sustainability Impact Assessment (SIA) is an increasingly accepted way for ex ante policy assessment and is rapidly spreading at different levels of governance (De Ridder et al. 2007; George and Kirkpatrick 2006). A wide range of approaches is available in the field of SIA including both analytical (e.g., model based) and qualitative and participation-based methods (Hacking and Guthrie 2002; Rotmans 1998). However, the specific context of policy making together with the specific set of sustainability issues makes every impact assessment unique and prohibits the development of "one fits all" methods for impact assessment (Scrieciu 2007).

Because of complex interdependencies and abstract thinking in SIA, a suitable mix of contextually adapted approaches and tools should be considered that together can support a sound and informed political decision-making. The choice of a particular approach for

impact assessments depends on various aspects, such as the specific decision context, regional aspects, preferences of stakeholders and decision makers, capacities, budget and the time available for the assessment. In many developed countries, for example, monitoring systems for environmental and socio-economic data have been established several decades ago, thus allowing the application of quantitative, computer-based assessment approaches.

However, data limitations still occur, for example, with regards to the availability of spatial land use data (Schmit et al. 2006). In addition, particularly if applied in multi-stakeholder contexts, SIA should not only include the provision of hard scientific facts, but should also be participatory and stakeholder-based in order to provide useful and transparent information to assist responsible decision making (Thabrew et al. 2009). In this context stakeholders are individuals, groups and organisations that are directly affected by decisions and actions or that have the power to influence the outcomes of these decisions (Freeman 1984).

In many developing countries, in contrast, the situation often differs widely from the described situation and requires new research strategies in order to understand fundamental interactions between nature and society (Kates et al. 2001; Lambin et al. 2001). According to Bacic et al. (2006), incomplete information is one of the main constraints for decision-making. Limited data availability and data quality often prevents the use of model-based assessments that is particularly the case in developing countries and requires instead softer approaches and more flexibility for SIA (Uthes et al. 2010). Indonesia serves as an appropriate example for the application of a participation-based SIA, where global changes and regional development have affected many urban and rural areas during the past.

The chosen case study Yogyakarta has experienced vast land use changes that were mainly caused by urban expansions, high population pressures and growing demands for natural resources. Population density in Yogyakarta region increased by 84% from 532 inhabitants per km^2 in 1970 to 979 person per km^2 in 2000 (Biro Pusat Statistik, 1970-2007). This rapid growth resulted in urban-rural expansions of built-up areas of 13% (1990-2006) (Sartohadi et al., 2008). Given the fact that most natural forests in this region have been cleared already (with the remaining area being under strong protection) the demand for settlement space is mostly met by changing rice paddies into settlements. As observed by Ding (2009) for another region, the loss of one unit of farmland due to urban

constructions has to be reclaimed somewhere else (i.e. protected forests). These developments brought a set of policy actions on the agenda of national and regional legislation bodies with the aim to limit the uncontrolled land use changes in the Region of Yogyakarta. However, such policies usually aim at one objective only, not taking account of the sustainability impacts through side effects on other land uses and related sectors.

In this paper, we describe how the Framework for Participatory Impact Assessment (FoPIA) method as developed by Morris et al. (2008) was adapted to assess two relevant land use policies in the Region of Yogyakarta, including the presentation of results of a first application and a critical reflection of testing this method in a non-European region for the first time.

2.2 The Study Area

The study was conducted in the Region of Yogyakarta (Figure 2.1). Yogyakarta is a densely populated area which is situated in Central Java, Indonesia, and is threatened by two main factors: high population pressure and frequently occurring natural hazards. High migration rates and economic growth have resulted in fast growing urban-rural expansion, mainly by land conversions from farmland and forest land into built-up areas (Dimyati et al. 1996). The main economic activities refer to the service sector, agriculture and industries, contributing to 39.6%, 15.1% and 13.9% of the regional gross domestic product (GDP), respectively (Biro Pusat Statistik, 1970-2007).

Figure 2.1. Location map of the case study area of Yogyakarta, Indonesia, including the administrative boundaries of districts.

The Region of Yogyakarta is comprised of five districts, with Bantul District in the south (506.86 km²), Sleman District in the north (574.82 km²), Kulon Progo District in the west (586.27 km²), Gunung Kidul District in the east (1,485.36 km²), and Yogyakarta City in the center (32.5 km²). The northern part of Yogyakarta reaches the foothills of the Merapi volcano, which is considered one of the most active volcanoes in the world (Lavigne et al. 2000). The last big eruption was dated back to 2006, which resulted in dramatic devastation of the Sleman and Bantul Districts, along with the suburbs of Yogyakarta City (Charbonnier and Gertisser 2008).

The elevation of the Region of Yogyakarta reaches 2,968 m above sea level. The climate is tropical, with average temperatures of 26.5 °C and a high mean annual rainfall of approximately 1,855 mm. The region is characterized by industries in Yogyakarta City and small-scale subsistence agriculture in the suburban and rural areas. From 1993 to 2006, urban built-up areas and new rural settlements doubled, while the area of agricultural land decreased by 25%. Rural areas, including home- or forest gardens, now account for 16%, and urban areas for 4%. The remaining area belongs to forests and coastal protection zones (Sartohadi et al., 2008).

Mixed farming systems with crop production, livestock, and home gardens (agroforestry systems) are the dominant farm types. These include paddy rice (*Oryza sativa*), mixed agroforestry systems with fruit trees, such as mango (*Mangifera indica*), banana (*Musa x paradisiaca*), and guava, and vegetables, including tomato (*Solanum lycopersicum*), chilli (*Capsicum annuum*), sweet potato (*Ipomoea batatas*), and cassava (*Manihot esculenta*), or annual crops, such as maize (Zea mays), beans (*Phaseolus vulgaris*), or groundnuts (*Arachis hypogaea*) under rainfed conditions. The livestock encompasses sheep, goats, beef cattle, dairy cows, and poultry.

2.3 Methods

2.3.1 The FoPIA approach

For the SIA of the selected land use policies, we applied the FoPIA approach, as described by Morris et al. (2008). FoPIA is a stand-alone method that can be used to structure and conduct an expert-based SIA. The implementation of FoPIA to the study area of Yogyakarta followed an integrated approach, as proposed by Reidsma et al. (2011), and was structured into three parts: (i) scenario development, (ii) specification of the sustainability context, and (iii) scenario impact assessment (Figure 2.2).
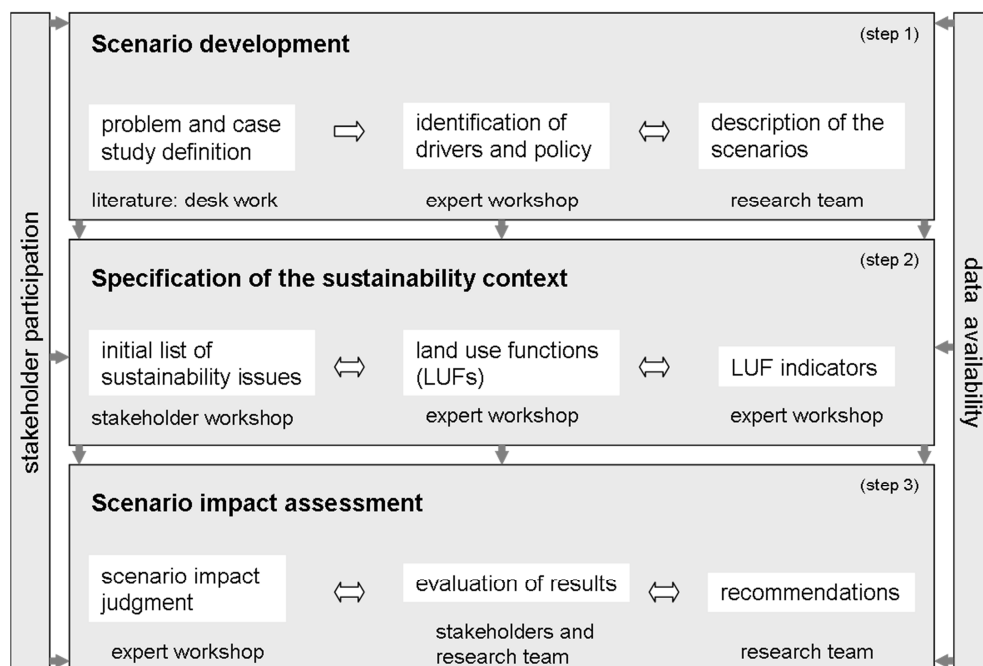
Figure 2.2. The implementation structure of the Framework for Participatory Impact Assessment (FoPIA) to the case study of Yogyakarta.

During a preparation phase, available information and materials were gathered and evaluated with a focus on the case study region and related problem issues. Several expert workshops were first used to select potential policy instruments and drivers of regional land use changes to be developed into plausible and alternative future scenarios.

For the specification of the regional sustainability context, we applied the Land Use Functions (LUF) concept (Helming et al. 2008; Paracchini et al. 2008; Pérez-Soba et al. 2008) that allows for a balanced classification of key sustainability issues into economic, social, and environmental assessment groups. For this purpose, a regional stakeholder workshop was used to identify and define a key set of LUFs and related assessment indicators.

The impact assessment was then conducted, in which the scenario impacts were judged and discussed for each LUF. We considered stakeholders as being rather indirectly affected by the selected policies, including representatives of those stakeholders being involved in the design and implementation of a policy (experts at the regional level) and experts who provide knowledge and insights on the local impacts (land use changes). The involvement of stakeholders from different levels in the process of SIA was stressed by Fraser et al. (2006) in order to avoid the neglection of either sustainability aspects. The

research team facilitated as a moderator during the FoPIA workshop and was responsible for the evaluation and analysis of assessment results.

2.3.2 Stakeholder Involvement

Stakeholder knowledge was used to obtain the required expertise and judgment about policy impacts on regional LUFs. For this purpose, a group of fourteen regional actors was identified and invited to conduct an expert-based SIA of selected land use policies in Yogyakarta. The expert panel included representatives of the Agricultural Agency of Yogyakarta (one expert), Bureau of Forestry (one expert), Bureau of Environmental Management of Central Java (one expert), Department of Natural Hazards (UGM) (two experts), Department of Hydrology (UGM) (two experts), Spatial Planning Agency of Yogyakarta (one expert), Spatial Planning Agency of Sleman District (one expert), Spatial Planning Agency of Bantul District (one expert), Spatial Planning Agency of Kulon Progo District (one expert), Spatial Planning Agency of Gunung Kidul District (one expert), and the NGO of Rural Development (PUDSEA) (two experts). The group covered representatives from different regional, environmental, social, and economic institutions, and was limited to a group size of not more than 15 experts to allow for active knowledge exchange during discussions.

2.3.3 Scenario Development

The definition of the case study specific problem issues and the driving forces behind these problems, as well as the delineation of the case study boundaries, were completed in the first step of the scenario development (Table 2.1). This first step was carried out by using available literature and materials from previous studies and available project reports. The selection of relevant land use policies was done during a prior expert workshop, in which local officials outlined the main characteristics and regional implementation of relevant land use policies. Based on these findings, we developed two policy scenarios: (1) S1, protection of forest land and (2) S2, conservation of paddy fields. We also used a 'Business As Usual' (BAU) scenario that served as a counterfactual scenario to assess scenario impacts in the absence of the policies. For all three scenarios, the year 2025 was chosen as the target year, since we intended to focus on medium-term sustainable development impacts.

The BAU scenario implied that land conversions continue as an ongoing trend, and that no additional or particular policy intervention was assumed. Land use maps were prepared to visualize possible scenario outcomes based on past land use changes and future trend extrapolations. For this purpose, the land use change modulator IDRISI was used to simulate changes of land use from 1993 to 2006 and projections toward 2025.

The S1 scenario had the goal of promoting forest areas and controlling illegal logging for environmental protection and economic development. Key scenario elements included a strong implementation of regional forest management and an increase of forest land by setting incentives on tree planting in rural areas and by promoting industrial timber production with high economic values (e.g., teak) and forest protection on upstream areas of watersheds and steep slope areas.

The S2 scenario aimed at the conservation of paddy fields with the main objective of ensuring regional food security. For the S2 scenario, we assumed a controlled and limited spread of settlements with key scenario elements that included a strong protection of paddy fields, incentives on paddy field farming through subsidized seedlings and fertilizer, and strong regulations and high taxing on land conversion.

Table 2.1. Scenario description.

	BAU scenario	S1 scenario	S2 scenario
Scenario type	business as usual	policy scenario	policy scenario
General characteristics	no policy	protection of forest land	protection of paddy fields
Drivers	economic development, population growth	economic development, population growth	economic development, population growth
Target year	2025	2025	2025
Implementation	-	since 1999, full implementation from 2009-2025	since 1992, full implementation from 2009-2025
Policy instrument	-	Law No. 41/1999	Perda DIY No. 5/1992

2.3.4 Land Use Functions and Indicators

As mentioned above, the concept of LUFs (Helming et al. 2008) is applied within FoPIA in order to link land use and sustainability. LUFs are defined as 'goods and services', which are provided by different land uses that summarize the most relevant economic,

social, and environmental aspects of a region (Pérez-Soba et al. 2008). The framework of the LUFs is applied to classify regionally relevant sustainability issues into social, economic, and environmental categories, and to display interim SIA results as the basis for stakeholder discussions. In this regard, LUFs can be seen as a pragmatic method for stakeholder-driven sustainability assessment of land use changes (Schößer et al. 2010).

To initiate a discussion of regional sustainability, a drafted set of LUFs was presented to the stakeholder group during the FoPIA workshop. In order to have an estimate for the regional importance of sustainability, a scoring exercise was used in which stakeholders were asked to point out their individual preferences on each LUF. The range of scores was from 1 to 10, where 10 denoted a very high importance and 1 denoted low importance. Scores were not exclusive, and could be attributed to more than one LUF. Scoring results were presented to stimulate discussions about different sustainability perceptions and to explore preferences for each LUF. Upon completion of this exercise and guided discussions of scoring results, the group was encouraged to move towards a shared understanding of the relative importance of each LUF. Based on these findings, a final list of nine region-specific LUFs was defined.

Each LUF needs to be represented by one corresponding indicator, as recommended by Morris et al. (2008), in order to have a precise criterion for handling the LUFs in the impact assessment. These indicators were selected and defined by local experts and the research team.

Selection criteria for appropriate indicators were as follows:

1. the indicator should be relevant to the corresponding LUF,
2. the indicator should be clear and understandable,
3. the indicator should be as precise as possible and measurable,
4. the indicator should not be redundant to other indicators.

2.3.5 Scenario Impact assessment

For the impact assessment, stakeholders assigned impact scores for each LUF indicator and corresponding scenario. It should be mentioned that the following scoring steps are not meant to be used in a statistical sense, but rather as a communication tool to support knowledge exchange and to stimulate discussions about possible scenario impacts. A scoring scheme from –3 to +3 was used to reflect, respectively, significant negative or positive impacts with the following scores: 0 = no impacts; –1 and +1 few impacts; –2

and +2 high impacts; and –3 and +3 extremely high impacts. On completion of the individual scoring, average impact scores for each scenario on each LUF indicator were calculated (to one decimal point) and presented to the stakeholder group. The group was asked to discuss the average scores and the various arguments behind the individual impact scoring results.

To initiate a discussion, the research team highlighted the contrasting positive and negative scoring results on each LUF and corresponding scenario. After exchange of arguments and open discussions, a second scoring round was undertaken in which experts could adjust the scores of the first scoring round. The arguments were summarized and reported by the research team, and the results were adjusted upon common agreement of the group. The workshop concluded with a summary presentation of the workshop results and a final discussion. Stakeholders were given the opportunity to give final comments on the impact assessment results.

2.4 Results and Discussion

2.4.1 Land Use Functions and Indicators of Yogyakarta

The identification of LUFs started prior to the FoPIA workshop with a brain-storming session by the local research team, in which the European LUFs framework (Pérez-Soba et al. 2008) was adjusted towards the regional sustainability context of Yogyakarta.

As a result of this adaptation process, a set of nine LUFs was defined for the region of Yogyakarta. For each sustainability dimension, we identified the following LUFs (see also Table 2.2):

- Social land use functions: provision of work, quality of life, and food security;
- Economic land use functions: non-land-based activities, land-based production, and infrastructure;
- Environmental land use functions: provision of abiotic resources, provision of biotic resources, and maintenance of ecosystem processes.

The LUFs required some modifications with particular regard to the different cultural attitudes and sustainability targets of the Region of Yogyakarta compared to European regions. The major changes were considered for the social dimension in which the two LUFs, quality of life and food security, were newly introduced from the perspective of a developing country. Although the social LUFs are closely dependent on economic

aspects, they reflect the main social attributes of the region of Yogyakarta, with respect to basic subsistence needs (food security) and livelihood (quality of life and employment).

In contrast, the economic LUFs mainly cover aspects of economic growth (e.g., more roads and transportation systems, intensified agricultural production systems) and related structural changes (i.e., increase in built-up areas). Environmental LUFs refer to basic ecological functions (e.g., provision of natural goods, such as fresh water supply) and natural processes (an intact ecosystem: e.g., undisturbed water cycle and natural succession processes).

Results of the scoring exercise of stakeholders' perceptions towards the regional importance of each LUF (see Table 2.2) revealed that food security (8.79), non-land based activities (8.50), infrastructure (8.14), the provision of abiotic resources (e.g., water availability) (8.00), and the maintenance of ecosystem processes (e.g., provision of clean water) (8.14) appeared to be most important in Yogyakarta. This seems to be reasonable because regional food production dropped as a result of conversions of crop-land to urban areas with consequences for regional food supply and self-sufficiency. Urban related LUFs were considered highly important for non-land based activities and infrastructure, since these two LUFs reflect the recent economic activities. The supply of clean water appeared to be a crucial aspect in the Yogyakarta region, due to high urbanization rates and lagging sanitation systems. These sanitation systems are considered a general problem of fast growing cities in developing countries (Chen 2007).

In contrast to this, provision of work (7.86), quality of life (7.79), land-based production (7.64), and the provision of biotic resources (7.71) were scored to be less important, as indicated by lower scoring results. Stakeholder opinions brought forward stated that urban areas provide new job opportunities and better access to education and health care systems. These qualities were believed to improve the quality of life. With urban-rural land conversions, land-based production was scored less important, since urban areas provide new economic opportunities to rural society. The protection of natural land was scored as less important because the current priorities for sustainable development were given on urban and economic development issues.

The selected assessment indicators for each LUF were the following (see Table 2.2): employment rate, life expectancy, food availability per capita, size of built-up areas, land used for crop and economic production, road density, water availability, area size of natural land, and water quality.

Table 2.2. Land use functions (LUFs) and assessment indicators of Yogyakarta.

Land use function (LUF)	LUF relevance to Yogyakarta	Average score (regional importance)	LUF-indicator
1. *Provision of work*: provision of job opportunities for all in activities based on natural resources and related secondary sectors (e.g., agriculture, forestry, processing industries).	Land use policies affect land-based employment.	7.86	Regional employment rate [%]
2. *Quality of life*: refers to an improved livelihood and a fulfilled minimum standard of living through that enables a longer life expectancy (e.g., health care, education, time for recreation, improved housing facilities).	Life expectancy is a major attribute of improved quality of life.	7.79	Life expectancy [age]
3. *Food security*: sufficient food availability in terms of food quality and quantity that meets the minimum daily needs for human life; food should either be produced at local level or imported from other regions.	Ensuring food security is the first concern of rural society.	8.79	Food availability [kg per capita/ year]
4. *Non-land based activities*: including residential and land independent production systems, provision of space where residential, social and productive human activity takes place in a concentrated mode (e.g., settlements, industries and urban areas).	Built-up areas reflect the economic development situation.	8.50	Land area used by build-up areas [GDP output/ region^{-1}]
5. *Land-based production*: land that is used for production activities that do not result in irreversible change.	The majority of local population is involved in agricultural production.	7.64	Land used for crop- and economic production [km²/ region^{-1}]
6. *Infrastructure*: road networks, railways and public transport, involving a development that is largely irreversible.	Transportation means link the region with the outside areas.	8.14	Road density [km length/ region^{-1}]
7. *Provision of abiotic resources*: the role of land in regulating the supply of water.	Water availability is a basic natural resource.	8.00	Water availability [m3/ region^{-1}]
8. *Provision of biotic resources*: factors affecting the capacity of the land to support the provision of abiotic resources and ecosystem processes.	Protected land is a main indicator for an improved environment.	7.71	Natural land under protection [area size/ region^{-1}]
9. *Maintenance of ecosystem processes*: the role of natural cleaning processes to supply clean and fresh water.	Clean water is a major development target.	8.14	Clean water [m³]

2.4.2 Stakeholder-Based Scenario Impact Assessment

BAU scenario impacts (no policy)

The provision of work was seen as a way of improving under the BAU scenario (impact score +1.7; see Table 2.3). The main argument brought forward by the stakeholders was that the rapid economic growth, particularly in the urban areas of Yogyakarta, will provide new job opportunities to the local people. The close relationship between economic growth and employment was also observed, for example, by Firman (1994). However, it was mentioned that most of the new jobs created would be primarily run by migration workers and therefore, would be less available for local people.

Table 2.3. Scenario impact assessment results based on stakeholder judgments.

	BAU		S1		S2	
LUF	mean	min/max	mean	min/max	mean	min/max
LUF 1:	1.7	3/-2	-0.1	2/-2	0.9	3/-2
LUF 2:	-1.2	1/-2	1.8	3/0	1.8	3/0
LUF 3:	-2.1	2/-3	0.4	3/-3	2.5	3/1
LUF 4:	1.8	3/-1	0.4	3/-2	0.1	3/-2
LUF 5:	-2.0	3/-3	-0.1	3/-3	1.7	3/-3
LUF 6:	1.5	3/-3	0.4	3/-2	0.5	3/-2
LUF 7:	-2.1	-1/-3	2.2	3/0	0.1	3/-3
LUF 8:	-2.2	-1/-3	2.0	3/-1	-0.1	3/-3
LUF 9:	-2.2	0/-3	1.9	3/-1	-0.6	3/-3

The negative impacts on quality of life for health issues (impact score –1.2) were expected, due to the increasing risk of natural disasters, such as landslides and floods, as a result of ongoing and uncontrolled land conversions (built-up and deforestation). Some stakeholders and a study by Hidajat (2007) saw possible improvements to handle such health threats via higher education.

A common agreement that is also reported by several studies (see Chen 2007; Hadiprayitno 2010; Herlina 2004) was that ongoing land conversions of crop-land into build up areas put local food security at a high risk (impact score –2.1). However, a positive aspect mentioned in this regard was the likely introduction of new and improved technologies (e.g., high yielding varieties and fertilizers) that would increase the land productivity and food output per land unit.

The non-land-based development was considered to improve during the coming years, due to high economic growth in Yogyakarta (impact score +1.8) (see Firman 2004; Kusago 2002; Sartohadi et al., 2008). Nevertheless, it was mentioned that the increasing development of settlements in the most developed district of Yogyakarta (Sleman District) towards the Merapi volcano would bring a higher risk for possible drawbacks and urban devastations due to natural hazards. The stakeholders' impact scores for the land-based production ranged from –3 to +3, with different underlying arguments, but with negative scenario impacts on average (impact score –2.0).

The main negative arguments were that agriculture will experience dramatic losses of productive land due to high land conversion rates and the fast expansion of urban areas into rural regions. This argument was also supported by Hadiprayitno (2010) and Herlina (2004). Positive arguments referred to improved and intensified agricultural practices that may be reasonable if new techniques will be introduced (Firman 1994).

With regard to infrastructure, developments were expected to be positive (impact score +1.5), and the main argument was that the government, due to Yogyakarta's rapid economic development, will increase investments into road and transportation projects (Kusago 2002). Again, some stakeholders mentioned that natural hazards may cause serious damage to high-risk development sites, particularly in those which are close to the Merapi volcano.

The provision of abiotic resources, including a guaranteed supply of natural water resources, was shown to experience serious regional problems (Firman 2004) with a high negative impact score (–2.1). The main argument was that illegal forest logging in the headwater catchments caused by increasing population pressure and higher demands for natural resources will dramatically increase. Although water availability was not considered an issue during the past, because of high regional rainfall, increasing demand for water resources and a continuing disturbance of natural water systems became a major concern nowadays.

Similar negative impacts were also seen on the provision of biotic resources (natural and protected areas), with a negative impact score of –2.2, and on the maintenance of ecosystem processes (impact score –2.2). It was argued that land conversions and increasing establishments of urban settlements on mountainous upstream areas causes land degradation (landslides) and water pollution, with related loss of natural land (see Smith et al. 1999).

In addition to the mainly negative arguments on all environmental functions (impact scores from –3 to 0), it was stated that rural people may become more aware of their environment through negative experiences, training, and education (see Hidajat et al. 2007), and because of this, locals may handle natural resources more sustainably in the future.

S1 scenario impacts (forest protection)

The average scoring impacts of the S1 scenario on the provision of work were slightly negative (–0.1; see Table 2.3). However, the range of given scores was wide (–2 to +2). The negative impact scores were mainly based on the opinion that forest land, which is usually under protection, will not provide employment possibilities. The positive argument referred to a forest protection program, called 'GERHAN', which is run by the government, and to the expansion of industrial forest plantations for teak production that provide some job opportunities to the region. Quality of life was considered to perform positively under the S1 scenario (impact score +1.8).

The most common opinion was that forest land will reduce the risk of natural disasters, such as landslides or floods (Bruijnzeel 2004), and hence limit the danger for human life. Based on the opinion that large areas of forest land will be used as integrated agroforestry systems or so-called household gardens, the corresponding scoring argument for food security (impact score +0.4) was positive on average. These combined agriculture-forest systems have a long tradition in the Region of Yogyakarta (Palte 1988) and provide various fruit products, such as mango, papaya, coconut, banana, and other tropical fruits.

Non-land-based production was expected to increase (impact score +0.4), based on the general trends of the BAU scenario and the assumption that non-land-based production is intensified due to the shift of agriculture activities to more off-farm activities in the service and industry sectors. This development trend was considered to benefit for the overall economic development (Firman 2000; Steffan-Dewenter et al. 2007).

Land-based production was predicted to decline (impact score –0.1) and was underpinned by the argument that regional land use develops towards more urban and related built-up areas in the surroundings of Yogyakarta City (Firman 2000). Infrastructure was expected to progress further in development through structural changes and government investments (Firman 2000; Firman 2004).

The provision of abiotic and biotic resources and the maintenance of ecosystem processes were all seen to improve under the S1 scenario (impact scores of +2.2, +2.0, +1.9, respectively). The main arguments behind these impact scores were that the conservation of forest land will contribute toward the fulfillment of key ecosystem processes. For example, forest land will stabilize hydrological functions at watershed level including water infiltration into the soil and related groundwater recharge, and provide natural filtering mechanisms for fresh water (Bruijnzeel 2004).

S2 scenario impacts (paddy field conservation)

The provision of work was scored to improve under the S2 scenario (impact score +0.9; see Table 2.3). The main argument mentioned by the stakeholders was that the Region of Yogyakarta, as a national food bowl for rice production (Dimyati et al. 1996), has a long tradition of agriculture. Agriculture has always provided work to rural society. Some stakeholders, however, raised their concerns about paddy field cropping because agriculture activities and related economic returns may not held pace with the overall rapid economic growth in Yogyakarta, and many farmers tend to leave on-farm activities for alternative off-farm jobs (Firman 1994; Firman 2000). Quality of life was expected to perform positively under the S2 scenario (impact score +1.8). The common opinion was that paddy fields, if properly managed, may reduce the risk of landslides and floods, and hence limit the risk of natural disasters on human health. The food security situation was believed to improve if paddy fields will be maintained and their productivity increased through technological innovations (Hadiprayitno 2010; Herlina 2004).

On average, the non-land-based production, based on the opinion that alternative off-land sectors, such as industries and services are intensified (Firman 2004), was thought to slightly increase (impact score +0.1). The land-based production was expected to increase (impact score +1.7); this opinion was underpinned by the argument that regional paddy field production is intensified and supported towards national food security. Infrastructure was expected to create some developmental progress through governmental construction programs (impact score 0.5), which link remote rural regions to other areas.

The provision of abiotic resources was expected to slightly improve (impact score of +0.1) on average, although scoring arguments were varied. To the stakeholders' opinion, paddy fields may have either effect on regional water availability. On the one hand, water resources are restored on paddy cultivations (Yoshikawa and Shiozawa 2006), but on the

other hand, water is also intensively used for crop production and is less available for other uses. The provision of biotic resources and the maintenance of ecosystem processes were expected to slightly decline (impact scores of –0.1, –0.6, respectively). The common opinion was that paddy fields fulfill less natural functions when compared to those of natural land, and contribute to lower water quality, due to use of chemicals and fertilizers.

2.4.3 Overall Performance of LUFs under the Three Scenarios

Impacts of the BAU scenario resulted in negative impacts on two social LUFs (quality of life and food security), an economic LUF (land-based production), and all environmental LUFs. The provision of work (social LUF) and the economic LUFs, non-land based production and infrastructure, were assessed to improve. The scenario impact performance illustrates a positive impact result of the S1 scenario on seven out of nine LUFs, which particularly includes the environmental LUFs and excludes the social LUF, 'provision of work', and the economic LUF, 'land-based production'. Impacts of the S2 scenario were expected to have positive impacts on seven out of nine LUFs, which, in this case, particularly refer to the social and economic dimension and exclude the environmental LUFs, 'provision of biotic resources' and 'maintenance of ecosystem processes'. As an overall outcome, S2 showed the highest positive impacts on most LUFs compared to the BAU and S1 scenarios. Nevertheless, the two environmental LUFs, 'provision of biotic resources' and 'maintenance of ecosystem processes', were expected to experience negative impacts in the scenario S2.

The results of the stakeholder-based impact assessment were shown to be differentiated for each scenario. The general outcome seems to be plausible, although the impact arguments varied among workshop participants.

The general reasons behind the negative impacts on the environmental LUFs and related negative impacts on the quality of life appeared to be well understood by most stakeholders. The land conversion towards built-up areas appeared to be a major threat for regional land-based production, and consequently, land conversion affects food security. The positive performances of the economic LUFs, non-land based production and infrastructure, and the social LUF, provision of work, appeared to be reasonable, as a result of rapid economic development.

Under the S1 scenario, the social LUF, provision of work, was expected to experience negative impacts. Forest plantations and protected forest land were considered to provide

only a few job opportunities that cannot supply sufficient job possibilities to a growing population size. The scenario S1 was considered to contribute to local food security through food harvests from agroforestry systems and forest gardens - whereas the economic output with regard to land-based production was considered to develop negatively. The social LUF, 'quality of life', and the environmental LUFs were all expected to improve by meeting the goals of soil and water conservation strategies.

The S2 scenario was expected to have negative impacts on two environmental LUFs ('provision of biotic resources' and 'maintenance of ecosystem processes'). Paddy field cultivation was considered to have rather negative effects on natural ecosystem processes and also contributes to water pollution. The positive performance of all social and economic LUFs appeared to be reasonable for the 'provision of work', 'quality of life', 'food security', and 'land-based production'. Impacts of the S2 scenario were assessed to be moderate on 'non-land based production' and 'infrastructure' as a result of some economic growth, and also slightly positive on the environmental LUF, 'provision of abiotic resources', as a result of water management strategies.

2.4.4 Reflections on the FoPIA Approach

From a methodological point of view, we want to point out some critical reflections on the FoPIA method and its transferability success to a tropical region in South-East Asia (i.e., Indonesia). The overall results of the impact assessment appeared plausible, and the reactions of the stakeholders involved in the assessment process allow us to conclude that a participation-based method is suitable for the context described. A particular advantage of the chosen FoPIA method is that in the absence of transparent monitoring and background data, the consultation of stakeholders from different backgrounds ensures that a wide range of information is gathered and the risk of overlooking important causal relationships is reduced.

After the FoPIA workshop, a team-internal evaluation by the participating expert group showed the following positive aspects: FoPIA provides a well-structured guideline to conduct an SIA, offers a high degree of transparency, produces quick results, and is a good approach for interdisciplinary knowledge exchange with regard to a better understanding of the sustainability concept. The stated negative aspects of this method referred to the limited number of indicators, complexity of scenarios, different sustainability issues, and limited time budget for some experts, as they had to spend a full

day on the workshop. The quantification of results remains limited and instead, requires a more qualitative interpretation. The inclusion of social LUFs appeared to be crucial by revealing sensitive impact issues that were of particular importance to assessing urban-rural sustainability in an integrated way; however, a close link to economic LUFs remains.

Nevertheless, FoPIA requires careful preparation, critical evaluation, and feedback communication of the final results. If FoPIA is used as a stand-alone method, it is recommended that one pay particular attention to the stakeholder selection process (i.e., ensure that a balanced and interdisciplinary selection is made) and to make enough time available to carefully discuss all scoring extremes and stakeholder arguments. In this study, we found it helpful to include local knowledge from different levels that supported and complemented the implementation of the SIA process; these actions allowed for a critical evaluation and reflection of the FoPIA results.

2.5 Conclusions

The intention of this study was to perform an SIA of two alternative land use policies by focusing not only on environmental issues, but also on social and economic aspects. We have chosen a qualitative impact assessment approach with quantitative elements using local stakeholder knowledge. The chosen approach proved to be useful in this particular assessment context, which is characterized by low data availability and the necessity of cross-disciplinary integration of knowledge. The key outcomes of our study are therefore not only the assessed impact scores, but moreover the arguments behind them:

Firstly, the stakeholders generally believed that the conservation of forest land or paddy fields had rather positive impacts on most social and ecological land use functions in Yogyakarta, but some stakeholders also indicated that land-based production may not hold pace with overall economic development. In fact, many rural people tend to sell their land to receive ad hoc cash and may reorient to better paid off-farm jobs. This is supported by other studies and the fact that rural income sources, such as small-scale agriculture or eco-tourism alone, do not provide sufficient economic returns for larger population numbers.

Secondly, uncontrolled land conversion and natural hazards remain two major problem issues in Yogyakarta. On the one hand, high population pressure and increasing demand for land cause the cultivation of land at risky sites. On the other hand, unexpected natural

disasters can set incentives for people to concentrate on specific sites, which often leads to uncontrolled land degradation.

Recommendations drawn from our study are based on stakeholders' preferences and their scenario impact judgements and include the following:

- to ensure regional food security by maintaining and conserving paddy fields so as to supply sufficient food to the region,
- to allow for regional development, including built-up and infrastructure projects, but to carefully consider potential negative side effects and to establish spatial measures that monitor and control land conversions from rural to urban land use,
- to maintain key ecosystem processes by protecting remaining forest land, particularly in the headwater catchments of Yogyakarta, and thereby reduce the risk of landslides and floods,
- to promote integrated agroforestry systems and home gardens that should contribute to some local socio-economic benefits to rural society, while maintaining key environmental land use functions.

Further research should study more of the differentiated land conversion impacts on regional (i) clean water supply, (ii) profitability, and (iii) food security to inform decision makers and to improve land management practices at a regional level. On a methodological level, some practical issues should be considered: the definition of the optimal group size of stakeholders that should be included into the different steps of the SIA process, the design of policy and land use change scenarios, the identification and selection of appropriate sustainability indicators, and the determination of how much preparation is needed in order to make the workshop most effective, but at the same time, maintain stakeholder motivation. Furthermore, it remains to be seen whether the method itself can possibly serve as a decision support instrument for stakeholders, or whether the exercise remains on an academic level. For future applications, this ambiguity needs to be worked on, so as to clearly make use of this tool. FoPIA has a high potential to guide stakeholders' discussions, throughout an impact assessment, towards the different dimensions of sustainability. It should be kept in mind that FoPIA puts the most emphasis on the impact assessment procedure itself and the 'participatory' process of impact discussions on each of the scenarios and 'affected' indicators. These potentials need to be sharpened while the deficiencies need to be reconsidered and further developed for future applications.

Chapter 3

Participatory impact assessment of soil and water conservation scenarios in Oum Zessar watershed, Tunisia

Abstract

Environmental threats and progressive degradation of natural resources are considered critical impediments to sustainable development. This paper reports on a participatory impact assessment of alternative soil and water conservation (SWC) scenarios in the Oum Zessar watershed, Tunisia. The first objective was to assess the impact of three SWC scenarios on key social, economic and environmental land use functions. The second objective was to test and evaluate the applicability of the 'Framework for Participatory Impact Assessment (FoPIA)' for assessing scenario impacts in the context of a developing country, in this case Tunisia. The assessed scenarios included: the originally planned SWC policy implementation at 85 % coverage of arable land of the watershed, the current implementation (70 %), and a hypothetical expansion of SWC measures to the entire watershed (100 %). Our results suggest that implementation of the SWC policy at 100 % coverage of arable land achieves the maximum socioeconomic benefit. However, if stakeholders' preferences regarding land use functions are taken into account, and considering the fact that the implementation of SWC measures also implies some negative changes to traditional landscapes and the natural system, SWC implementation at 85 % coverage of arable land might be preferable. FoPIA approved to be a useful tool for conducting a holistic sustainability impact assessment of SWC scenarios and for studying the most intriguing sustainability problems while providing possible recommendations towards sustainable development. We conclude that participatory impact assessment contributes to an enhanced regional understanding of key linkages between policy effects and sustainable development, which provides the foundation for improved policy decision making.

3.1 Introduction

Environmental threats and the progressive degradation of natural resources pose critical impediments to sustainable development, particularly in the arid regions of Tunisia. The Oum Zessar watershed in the Médenine region in southeastern Tunisia faces severe land degradation problems due to limited water resources, growing population, increasing land competition and agricultural intensification (Ouessar et al. 2009; Schiettecatte et al. 2005).

In response to ongoing degradation problems, the Tunisian government has invested 562 million Dinars (= US $389 mil) since 1990 on soil and water conservation (SWC) measures at the national level (Sghaier et al., 2009). The major goals of the SWC policy

are to tackle land degradation in a vulnerable environment and to enhance the capacity of the land for agricultural production through the promotion of both traditional and modern water-harvesting techniques (Ouessar et al. 2009). Policy initiatives have mainly been realised through subsidies provided by the government. These have included regional infrastructure projects, subsidies and financial support for farmers for constructing and maintaining water harvesting facilities at the local level (Fleskens et al. 2005; Ouessar et al. 2004; Schiettecatte et al. 2005). Large parts of the Oum Zessar watershed were enrolled in the SWC policy program and have since experienced dynamic changes in land management due to the reorientation of agricultural production from small-scale and subsistence farming towards market-oriented agriculture.

Regional decision makers are currently evaluating the `success of the SWC policy´ and considering a possible expansion of the SWC policy in the Oum Zessar watershed. To ensure policy efficiency, decision makers demand a comprehensive and reliable assessment of the possible impacts of policy changes on the economic, environmental and social components of development (O'Farrell and Anderson 2010; Pope and Grace 2006; Scrieciu 2007). An impact assessment of the SWC policy towards sustainable development could support the decision-making process. In this study, we demonstrate the use of the Framework for Participatory Impact Assessment (FoPIA) by conducting a case study-based sustainability impact assessment of SWC scenarios in Oum Zessar watershed. For this purpose, FoPIA, which was originally developed for the European context (Morris et al. 2011), was adapted to the regional conditions in Oum Zessar watershed.

Sustainability impact assessment (SIA) is an increasingly accepted way of incorporating this holistic perspective into policy assessments (Boulanger and Brechet 2005; De Ridder et al. 2007; George and Kirkpatrick 2006). Currently, a wide range of methods and tools are available in the field of SIA including both analytical (i.e., computer-based models) and more qualitative methods (Hacking and Guthrie 2002; Rotmans 1998). Although there is no common procedure for SIA, most approaches characterise sustainability in terms of indicators (Binder et al. 2010; Diaz-Balteiro and Romero 2004; Paracchini et al. 2011; Walter and Stutzel 2009; Wiggering et al. 2006). The choice of a particular SIA approach depends on multiple considerations, such as the specific decision context, regional conditions, stakeholder preferences, capacities, data availability, budget and the time available for the assessment (König et al. 2010). According to Bacic et al. (2006),

incomplete information is one of the main constraints on decision-making. To derive useful information for decision making, it is therefore necessary to understand causal linkages between human action and regional consequences (see, for example, Halvorson et al. 2003; Hill et al. 2006; Zhu and Dale 2000).

Much progress has been made in the study of complex human-nature relationships and interactions (see, for example, Bennett et al. 2009; Liu et al. 2007; Walmsley 2002). However, the scope of coverage of analytical and quantitative computer-based tools often remains limited due to predefined and tool-specific settings, particularly in ex ante studies (Uthes et al. 2010), and because social considerations are still rare (Linkov et al. 2006). This appears to be the case particularly in developing countries (Reidsma et al. 2011), and new research strategies are required to understand the fundamental interactions between nature and society (Kates et al. 2001; Lambin et al. 2001). Sheate et al. (2008) found that stakeholder participation can improve the understanding of causal linkages between land use and sustainability at the regional level. There is growing evidence that stakeholder participation can enhance decision-making processes (Reed 2008). Therefore, to promote responsible and transparent decision making, SIA requires participatory, structured and well-tested approaches that not only produce hard data but also integrate the knowledge of the different stakeholders and disciplines (Thabrew et al. 2009; Zhen et al. 2009b).

Until now, most studies on soil and water conservation issues in the Oum Zessar watershed have focused on either environmental or economic aspects, for example, on the regional water balance (Schiettecatte et al. 2005), the economic productivity of olive trees (Fleskens et al. 2005) or the profitability of different water-harvesting systems (Ouessar et al. 2004). Integrated impact assessments that consider the social, economic and environmental dimensions together are still missing.

This study was conducted as part of the EU funded LUPIS project (Land use Policies and Sustainable Development in Developing Countries, www.lupis.eu), which aims to develop integrated assessment tools in developing countries. The LUPIS project was built upon two larger EU projects: the SEAMLESS Integrated Framework (SEAMLESS-IF), concentrating on the agriculture sector across scales (Van Ittersum et al. 2008), and SENSOR, which focuses on multiple land use sectors at the regional scale (Helming et al. 2011a). Both approaches are indicator-based, integrate different quantitative and qualitative models and tools (Uthes et al. 2010) and structure the assessment procedure

according to the 'Driver-Pressure-State-Impact-Response' (DPSIR) framework of Smeets and Weterings (1999).

The application of FoPIA method proposed here has been developed as part of the SENSOR project mainly to complement the development of computer-based SIA tools with stakeholder knowledge, thereby allowing causal chains and assessment results to be verified from a regional perspective. However, FoPIA could also be used to conduct a stand-alone impact assessment, for example, to study the effect of spatial planning policies on rural-urban sustainability in Indonesia (König et al. 2010).

The first objective of our study was to conduct a stakeholder-based sustainability impact assessment of three alternative SWC scenarios in the Oum Zessar watershed. FoPIA was adapted to the regional sustainability context and implemented to elaborate the alternative SWC scenarios and develop a set of regional assessment indicators, thereby assessing and exploring the possible impacts of the three SWC scenarios on sustainable development. Based on the results of the assessment, possible compromises and implications for regional land management and sustainable development are discussed. The second objective was to evaluate the applicability of the FoPIA method for impact assessment in the context of a developing country for the case of the Oum Zessar watershed in Tunisia.

3.2 Methods

3.2.1 The FoPIA approach

The FoPIA approach provides a structured sequence of methods for conducting sustainability impact assessments of land use policies (König et al. 2010; Morris et al. 2011). FoPIA consists of two assessment directions: firstly, a discursive examination of causal relationships and attributions of changes between human activities and sustainability targets, and secondly, the exploration of scenario impacts and possible trade-offs on defined sustainability targets at the regional level.

The implementation structure of FoPIA at the case study level has been adapted from Reidsma et al. (2011) and follows three main steps: (i) scenario development, (ii) specification of the sustainability context, and (iii) scenario impact assessment (Figure 3.1). The whole process is driven by regional data availability and the active participation of stakeholders in each assessment step. In addition to an extended preparation phase (mainly steps i and ii) to implement FoPIA at the case study level and an assessment

outcome evaluation phase, a two-day stakeholder workshop is at the core of this approach to scenario impact assessment.
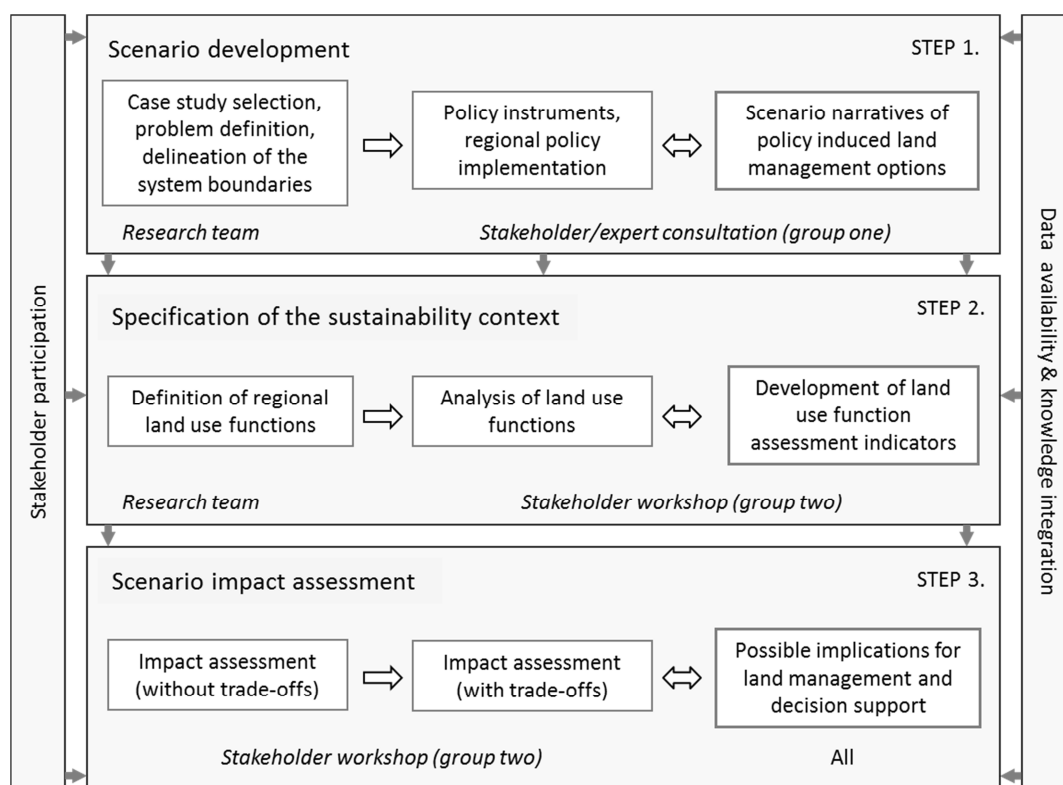
Figure 3.1. The implementation structure of the Framework for Participatory Impact Assessment (FoPIA) to the case study of Oum Zessar watershed, Tunisia.

3.2.2 Stakeholder participation

Stakeholders are defined as individuals, groups, and organisations that are directly affected by decisions and actions or that have the power to influence the outcomes of these decisions (Freeman 1984). In this study, the stakeholder participation included: first, the consultation of individual local actors (mainly stakeholders and experts from regional land administration and research institutions) to support the development of regional SWC scenarios (group one); second, a group of ten stakeholders was invited to perform the SWC scenario impact assessment, including regional authorities and administrators responsible for either the preparation of policy guidelines or regional policy implementation (group two).

The stakeholder selection criteria for the second group were: (i) the individual participant should have a strong background and knowledge about regional land use and SWC policy, and (ii) the group should be balanced among social, economic and environmental

disciplines. The invited stakeholder group included six representatives from the Regional Administration of Agricultural Development (CRDA), two representatives of the South Development Office, Médenine (ODS), one expert of the Tunisian Union of Agriculture and Fishing (UTAP), and one expert of the Ministry of Environment and Sustainable Development (MEDD).

3.2.3 Scenario development

The scenario development started with the selection of the case study region. For this study, the Oum Zessar watershed was selected as a case study of a region with an arid climate and low productivity land. The reason for selecting this case study was to assess the regional impacts of the SWC policy in terms of social, economic and environmental sustainability and to test the applicability of the FoPIA method in a North African country for the first time. The system boundaries were defined at the watershed level, which also represents an administrative level of policy implementation. The case study area is characterised by small-scale agriculture that is dominated by crop production, livestock farming, agro-forestry plantations with olive trees, and a growing sector of export-oriented date production. Water scarcity is considered the main limiting economic production factor for land, and rainfall varies between 150–230 mm rainfall per annum (Ouessar et al. 2004). The population size was 24.188 in 1994 and reached 31.693 in 2008 (estimated based on INS[3] statistics 1994-2004), with an average growth rate of 2.3% per annum.

Policy instruments

As a response to high climate vulnerability in economic land production, the Tunisian government launched a policy on soil and water conservation (SWC) measures. The SWC policy started in the 1990s through a two-decade strategy (1990-2000 and 2001-2011, Stratégies Décennales de CES) with the following goals (Ouessar et al. 2009; Sghaier et al., 2009):

- To protect arable lands against erosion, control water flux, increase land utilisation through the construction of water harvesting facilities, including (for example) field terraces in mountainous terrain (jessour system), large earthen dams (tabias), and groundwater recharge gabions (stone walls).

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[3] National Institute of Statistics, Tunisia

- To have farmers take responsibility for SWC with anti-erosion technologies according to the characteristics of their farms.
- To create private companies that specialise in SWC implementation and maintenance.

Scenario narratives

Together with regional land administration experts and the Institut des Régions Arides, we developed a set of three alternative SWC scenarios for Oum Zessar watershed, including (i) the originally planned SWC implementation, (ii) the SWC actually implemented (in 2009) and (iii) a hypothetical expansion of SWC policy measures. We selected 2015 the target year for all scenarios, considering the following assumptions: the current implementation rate of SWC measures in 2009 was approximately 70% of manageable land in the watershed and will not be changed until 2015. This is represented by the scenario of actual implementation denoted 'SWC-70'. Following the intended policy target, the originally planned SWC implementation will reach 85% coverage of manageable land and is denoted the 'SWC-85' scenario. In addition to this, we also included a 'SWC-100' scenario, which represents a hypothetical expansion of SWC measures at full coverage of manageable land in the watershed. The latter scenario is currently under discussion and may be realised depending on the overall success, available budget and acceptance of this policy.

3.2.4 Definition of regional land use functions

To capture the notion of sustainable development, FoPIA makes use of the concept of land use functions (LUFs). LUFs are defined as 'goods and services', which are provided by different land uses that summarise the most relevant economic, social and environmental aspects of a region (Pérez-Soba et al. 2008). LUFs build upon the concept of *Ecosystem Services* but consider land use to be the main pressure for sustainability in rural areas, which can only be achieved if economic, social and environmental aspects are equally considered at the same level of investigation (Schößer et al. 2010). In this study, a generic set of nine social, economic and environmental LUFs as proposed in Pérez-Soba et al. (2008) was used as the starting point to define a regional set of LUFs for Oum Zessar watershed.

Analysis of land use functions

The regional set of LUFs was presented to a second group of ten invited stakeholders with different disciplinary backgrounds who were asked to assign weights of perceived regional importance to each LUF. The task was to assess differences in individual preferences and to invite stakeholders to enter a discussion on regional sustainability. A 0-10 scale was used to weight each LUF, where 0 indicates low importance and 10 very high importance. The same weight could be assigned to all LUFs. After a first scoring round, the average weights were presented back to the group. The ensuing discussions were used not only to clarify (and possibly adapt) definitions of LUFs, but also to reach a shared understanding of sustainability.

3.2.5 Development of land use function assessment indicators

Each LUF needed to be represented by one associated assessment indicator in order to have a precise criterion for handling the LUF in the impact assessment. According to Walz (2000), an indicator is a variable that can be used to describe the state of a system and its changes. A generic set of LUF indicators developed for the context of a developing country (Indonesia) was adapted from König et al. (2010) and presented to stakeholders in the second group in Oum Zessar watershed. The stakeholder group (group two) were given the opportunity to comment on and change indicators upon agreement among all group participants. This step was necessary to achieve a common understanding of the indicators, and it resulted in a commonly accepted set of LUF indicators.

The following criteria were applied to specify the selection process:

- the indicator should be relevant to the region and corresponding LUF
- the indicator should be clear and understandable to all stakeholders
- the indicator should be as precise as possible and measurable
- the indicator should not be redundant, i.e., covered by another indicator.

3.2.6 Scenario impact assessment

Impact assessment (without trade-offs)

The scenario impact assessment was divided into two assessment parts: (i) a scenario impact assessment without trade-offs and (ii) a scenario impact assessment with trade-offs. The final outcome of the impact assessment was evaluated by the research team and

considered in light of related studies and the available scientific literature. In the first step, a scoring scheme was used to assess both positive and negative impacts the SWC scenarios are anticipated to have on each LUF indicator using the following scoring scheme: 0 = no impact; - 1 and + 1 little impact; - 2 and + 2 high impact; and - 3 and + 3 extremely high impact. This scoring scheme entailed normalising the indicator values into one common scale. Upon completion of the individual scoring, average scores for the impact of each scenario on each LUF indicator were calculated (to one decimal point) and presented to the stakeholder group. To initiate a discussion, the moderator highlighted the contrasting positive and negative scores given by individual participants (scoring extremes) for each LUF and corresponding scenario. The stakeholder group was then asked to discuss the average scores and the various arguments behind the individual impact scoring results. Comments and individual impact arguments were recorded by the research team to underpin the assessment outcome with arguments and to note possible impact directions. After an exchange of arguments and open discussion, a second scoring round was undertaken in which group participants could adjust the scores of the first scoring round. The arguments were summarised and reported back by the moderator. The final results were adjusted upon common agreement of the group.

Impact assessment (with trade-offs)

In order to assess impact trade-offs, the second stakeholder group assigned 'priority' rankings to all the LUFs, this time in a clear hierarchical order. A scoring scheme of 1-9 was applied, where 1 indicates lowest priority and 9 indicates highest priority. The impact assessment results (scores) and LUF ranking scores were aggregated along the three dimensions of sustainability (economic, social, environmental) using the following equation:

$$ri_d = \sum_{f=1}^{n} r_{f,d} * i_{f,d} \qquad (1)$$

With: ri = ranked impact, r = priorities assigned to each land use function (ranking), i = average impact on each land use function as assessed by the stakeholder group (impact assessment), d = sustainability dimension (economic, social, ecological), f = land use function (n = 9). The scenario impact scores and LUF ranks were aggregated to allow the impacts to be interpreted according to the priorities assigned to each LUF and thereby

better understand the trade-offs associated with each scenario. This allowed for the alternative scenarios to be compared based on which possible implications for land management and decision support are under consideration.

3.3 Results

3.3.1 Specification of the sustainability context

Definition and analysis of land use functions

The definition of the nine regionally adapted LUFs for the Oum Zessar watershed is presented in Table 3.1. The results of the regional importance analysis differed markedly among the economic, social and environmental land use functions in the Oum Zessar watershed as indicated by the averaged weights (Table 3.1). These revealed that primary production, the provision of work, quality of life, and the provision of abiotic resources are considered to be most important in the Oum Zessar watershed. Infrastructure, industry and services were given the lowest importance and cultural identity, biotic resources and ecosystem processes were scored of medium importance. This set of preferences seems plausible because primary production (mainly agricultural output) and related job opportunities (mainly on-farm work) have a long tradition in this region and still play a key role in rural regions of Tunisia (see Dhehibi and Lachaal 2006; Ouessar et al. 2004). In contrast to this, stakeholders gave little weight to the LUF of 'industry and services' in this watershed because this area is remote and far away from industrial centres (Sghaier et al., 2009). Similarly, infrastructure was not perceived to be of great importance for regional sustainability because most economic products are sold at local and regional markets. The weight attached to 'cultural identity', considered by the participants as preservation of agricultural heritage (i.e., traditional pastoralism, ancient water harvesting techniques and, recently, olive groves), plays an important role at this level and was suggested to be difficult to capture.

Table 3.1. Definition and analysis of land use functions in Oum Zessar watershed.

Land use functions (LUFs)		Regional relevance	Average score	Changes in scores (+/-)
SOC 1:	Provision of work: provision of job opportunities for all in activities based on natural resources and related secondary sectors (e.g., agriculture, agro-forestry, processing industries).	Most people in the watershed rely on land-based job opportunities.	7,9	0,0
SOC 2:	Quality of life: refers to an improved livelihood and a fulfilled minimum standard of living that enables a longer life expectancy.	Life expectancy is a major attribute of improved quality of life.	7,4	-0,2
SOC 3:	Cultural identity: refers to the maintenance and development of cultural heritage and identity.	Cultural identity and traditions are very important to local people.	6,0	-0,6
ECO 1:	Industry and services: including land-independent production systems, provision of space where residential, social and productive human activity takes place in a concentrated mode (e.g., settlements, industries and urban areas).	Built-up areas reflect economic development.	5,1	+0,7
ECO 2:	Primary production: land that is used for production activities that do not result in irreversible change (e.g., crop- or forestland).	The majority of the local population is involved in agricultural production.	8,0	+0,4
ECO 3:	Infrastructure: road networks, railways and public transport involving development that is largely irreversible.	Transportation means link the region with the outside areas.	4,4	+0,3
ENV 1:	Provision of abiotic resources: the role of land in regulating the supply of water resources.	Water is a basic natural resource	7,7	+1,7
ENV 2:	Provision of biotic resources: factors affecting the capacity of the land to support the provision of abiotic resources and ecosystem processes.	Vegetation indicates an improved environment in arid regions.	6,3	+1,6
ENV 3:	Maintenance of ecosystem processes: to ensure natural processes such as natural water balance, nutrient cycles and natural succession processes.	Undisturbed land is less vulnerable to droughts and erosion.	6,3	+0,4

Changes in land use function preferences

After discussions and an exchange of arguments regarding the regional importance of LUFs, the changes in preferences adopted resulted in an increase of the average values for the environmental LUFs accompanied by increases in their economic dimension (Table 3.1). In particular, the two environmental LUFs, i.e., abiotic and biotic resources, were given higher scores than in the first round (+1.7 and +1.6), respectively. These changes were fostered by arguments brought forward by individual stakeholders stating that it is actually soil and water as natural resources that provide the basis for any primary production and related job opportunities.

By contrast, the scores for culture and quality of life decreased slightly (-0.2, -0.6), based on the comments that (i) culture is still and will be a substantial part of the regional society and hence does not really require particular attention, and (ii) the quality of life has already experienced some improvements compared to the past but still remains of crucial importance.

3.3.2 Development of land use function assessment indicators

The development and selection of assessment indicators was intensively discussed among the stakeholders, resulting in a commonly accepted set of nine land use function indicators (Table 3.2). There was more contention between stakeholders in relation to the selection of social indicators, whereas there was much less contention over the economic and (in particular) the environmental indicators.

Table 3.2. LUF assessment indicators and stakeholders' acceptance.

	LUF assessment indicator	Acceptance
SOC 1:	Regional employment rate [%]	Widely accepted
SOC 2:	Life expectancy [age]	Criticised but accepted
SOC 3:	Traditional techniques [status]	Relevant but difficult to measure
ECO 1:	Regional financial investments [td]	Accepted, but ambiguity was noted
ECO 2:	Income per farmer [td]	Accepted
ECO 3:	Road density [km length/ region^{-1}]	Accepted and specified
ENV 1:	Water availability [m^3/ land holding]	Widely accepted
ENV 2:	Vegetation cover [area size/ region^{-1}]	Widely accepted
ENV 3:	Natural land [area size/ region^{-1}]	Widely accepted

Social indicators

For the social dimension, employment rate was selected as the indicator for the LUF 'provision of work' because most people in the Oum Zessar watershed rely on regional job opportunities. Life expectancy was selected as the indicator for the LUF 'quality of life'. It was debated whether this indicator directly links to SWC policies. The indicator was finally accepted because life expectancy is a major attribute of improved quality of life and was expected to be affected by the promotion of SWC measures. For the LUF 'cultural identity', the proportion of traditional techniques used in land production was suggested to be the appropriate indicator. This indicator was accepted, but some stakeholders raised concerns about the feasibility of measuring this indicator.

Economic indicators

The amount of regional financial investment resulting in new built-up areas was chosen as the indicator for the economic LUF 'industry and services'. Although the difficulty of measuring this indicator was mentioned by one stakeholder, the group agreed that this indicator is highly relevant to representing the overall economic development situation. For the LUF 'primary production', income per farmer was defined the indicator. The majority of the rural population generates their income from land-based activities, i.e., mainly from agricultural production such as market-oriented olive and date production. Road density was chosen as the indicator for the LUF 'infrastructure', given the fact that road transportation provides the link between rural areas and the rest of the region.

Environmental indicators

For the environmental dimension, water availability per land holding was selected as the indicator for 'provision of abiotic resources.' This indicator was defined as 'water resource availability per land holding'. Permanent vegetation cover was selected as the indicator for 'provision of biotic resources', which is appropriate for measuring improvements of the overall environment in an arid region. Undisturbed land, lacking any anthropogenic activity, was chosen as the indicator for the LUF 'maintenance of ecosystem processes'. This indicator was widely accepted among the stakeholders because land becomes more vulnerable under certain land use management practices (for example, overgrazing due to high livestock density).

3.3.3 Impact assessment of SWC scenarios (without trade-offs)

In the first part, the results of the scenario impact assessment (without trade-offs) are shown in Table 3.3. A general observation from the results is that the assessed impacts increased, both positively and negatively, in correlation with the increasing promotion of SWC measures.

Impact of the SWC-70 scenario (actual policy implementation)

The current SWC policy implementation, represented by the SWC-70 scenario, was assessed to have a positive impact on eight LUFs, particularly on the social LUF 'cultural identity' and the economic LUF 'primary production'. A negative impact was assessed for the environmental LUF 'maintenance of ecosystem processes'. Cultural identity was judged positive as a result of little impact on land management or the maintenance of traditional land management practices. Primary production was assessed positive because agriculture provides the main income source for rural people. However, the LUF 'maintenance of ecosystem processes' was judged to have a slightly negative impact due to land intensification in agriculture.

Impact of the SWC-85 scenario (intended policy implementation)

Full realisation of the originally planned SWC policy implementation was assessed to have positive impact on eight LUFs, particularly on the social LUF 'provision of work', the economic LUF 'primary production' and the environmental LUF 'provision of abiotic resources'. In this scenario, 'cultural identity' was assessed to perform less positively as a result of the impacts of land management changes. The impact on the environmental LUF 'maintenance of ecosystem processes' was again assessed to be negative. Provision of work and primary production were assessed to be positively affected because more land will be available for cultivation, providing more rural jobs and better economic return. The provision of abiotic resources, i.e., water availability, was judged to improve as a result of improved soil and water conservation activities. Again, the 'maintenance of ecosystem processes' was assessed to experience a negative impact due to increasing land intensification, particularly in the agricultural sector.

Impact of the SWC-100 scenario (hypothetical expansion of SWC policy measures)

In the case where SWC policy measures are implemented at full coverage of manageable land in the watershed, the scenario was assessed to impact affect eight LUFs positively,

with particular regard to the social LUF 'provision of work', the two economic LUFs 'primary production' and 'provision of infrastructure', and the environmental LUF 'provision of abiotic resources.' In addition to having an intensified impact on all LUFs compared to the SWC-70 and SWC-85 scenarios, this scenario was particularly expected to benefit infrastructure in terms of new road construction to access land that would otherwise stay out of production. Again, 'cultural identity' was assessed as declining compared to the SWC-70 and SWC-85 scenarios as a result of continued changes in land management. The environmental LUF 'maintenance of ecosystem processes' was assessed as experiencing significantly negative impacts due to further increases in land disturbance as a result of land use intensification.

Table 3.3. Scenario impact assessment scores of three SWC policy scenarios.

	SWC-70	SWC-85	SWC-100
SOC 1	0,3	1,5	1,9
SOC 2	0,4	0,7	0,9
SOC 3	1,5	0,8	0,5
ECO 1	0,4	0,6	0,3
ECO 2	1,3	1,6	2,0
ECO 3	0,0	0,5	1,4
ENV 1	0,4	1,7	2,4
ENV 2	0,7	0,4	0,1
ENV 3	-0,1	-0,5	-1,4

3.3.4 Impact assessment of SWC scenarios (with trade-offs)

In this section, the results of the scenario impact assessment 'with trade-offs' are shown for each land use function (Table 3.4) and along the social, economic and environmental sustainability dimensions at higher aggregation (Table 3.5). At the aggregated level (Table 3.5), the promotion of SWC policy measures (SWC-85, SWC-100) was found to have benefits mainly on the social and economic dimensions. In the environmental dimension, the SWC-85 scenario, closely followed by the SWC-100 scenario, was assessed as providing the greatest benefit.

Social impacts

Our results revealed that expansion of the SWC policy has the potential to improve some social functions in Oum Zessar watershed, particularly with regard to the provision of

rural working opportunities (SOC 1) and an improved quality of life (SOC 2). The SWC's promotion of terraces for agricultural production, for example, enables the cultivation of land in areas that would otherwise stay out of production. The quality of life associated indicator 'life expectancy' was assessed to improve under the SWC policy based on the assumption that labour input per production unit could be reduced. Changes in traditional landscapes (SOC 3), however, were perceived as negative policy impacts.

Economic impacts

The impacts of the policy on economic land use functions were assessed as positive, mainly due to primary production (ECO 2) and the provision of infrastructure (ECO 3). Although the promotion of terraces will provide land for economic production, new roads will also be needed to access these areas. Although the stakeholders reported a slight increase in the industry and service sector (ECO 1) as a result of economic development, a shift from primary production to off-farm work is not yet observed in the case of Oum Zessar.

Environmental impacts

The impacts of SWC measures on environmental functions were primarily assessed as positive, particularly with regard to abiotic resources (ENV 1). Following the primary policy goal, the stakeholders judged that an expansion of SWC measures (SWC-85, SWC-100) would increase regional water availability in Oum Zessar watershed. However, negative impacts were assessed for the provision of natural vegetation (ENV 2) and some ecosystem processes (mainly the natural water cycle, ENV 3) due to anthropogenic activities and the disturbance of natural land.

Table 3.4. Weighted scenario impacts for each land use function.

	Ranking factor	SWC-70	SWC-85	SWC-100
SOC 1	0,60	0,18	0,90	1,14
SOC 2	0,56	0,23	0,39	0,51
SOC 3	0,49	0,73	0,39	0,24
ECO 1	0,36	0,15	0,22	0,11
ECO 2	0,63	0,81	1,00	1,25
ECO 3	0,36	0,00	0,18	0,51
ENV 1	0,56	0,23	0,96	1,35
ENV 2	0,55	0,39	0,22	0,06
ENV 3	0,39	-0,04	-0,19	-0,54

Table 3.5. Aggregated scenario impacts across the three dimensions of sustainability.

Scenario	Social	Economic	Environmental
SWC-70	1,1	1,0	0,6
SWC-85	1,7	1,4	1,0
SWC-100	1,9	1,9	0,9

3.4   Discussion

Sustainability impact assessment is an emerging field in the science-policy interface that meets the challenge of providing a 'holistic picture' of possible social, economic and environmental changes (George and Kirkpatrick 2006; Kates et al. 2001; Pope and Grace 2006). In Europe, ex ante policy impact assessments have become a mandatory instrument (Tscherning et al. 2008) due to the introduction of the EU impact assessment guidelines (Commission of the European Communities (CEC) 2009). In Europe, one main objective is to provide transparent information about possible policy effects and trade-offs and to improve the quality of policy decisions (De Smedt 2010). By contrast, in many developing countries policy assessments mainly focus on either environmental or economic aspects (see, for example, Baur et al. 2003; Kirkpatrick and Parker 2004; Reidsma et al. 2011). However, in both cases, a broad range of tools is available to conduct integrated assessments, although the balanced consideration of social, economic and environmental aspects is still hampered by the limitations of quantitative tools (Scrieciu 2007).

In the European context, advancements have been made in the analytical and integrated tools used to generate land use related policy assessments (see, for example, Sieber et al. 2008; Uthes et al. 2010; Van Ittersum et al. 2008). However, region- and tool-specific settings limit their "1:1" transferability to other regions where the input data and knowledge required to implement the tools is not available. The FoPIA method proposed here demonstrates how to conduct a holistic sustainability impact assessment of SWC policy by considering regional stakeholder knowledge as the main source of input information for the assessment.

3.4.1 Application of the FoPIA approach to Oum Zessar watershed

Our aim was to explore possible impacts of SWC policy on sustainable development in 2015 to support policy decision in the near future. Although it is well known that the

policy effects may take a long time on the ground, stakeholders were able to share their initial experiences with the SWC policy and discuss principle insights regarding causal linkages between regional policy-land-sustainability relationships. In general, the SWC policy was assessed to have achieved its main goals of enhancing the capacity of the land for production. The introduction of field terraces and other water-harvesting techniques enables the use of land in arid areas that would otherwise stay out of production (Amsalu and de Graaff 2007; Fleskens et al. 2005) and also reduces the risk of harvest losses during dry years while locally stabilising the groundwater level (Schiettecatte et al. 2005). According to Hill and Woodland (2003), these jessour systems are also difficult and costly to maintain while frequently suffer sedimentation problems.

At the national level, agricultural productivity increases an average of three percent annually (Dhehibi and Lachaal 2006), which indicates the potential for economic land production. The use of water-harvesting techniques in southern Tunisia has a long tradition (Hill and Woodland 2003), and farmers are well equipped to produce food and survive in such harsh environmental conditions. However, with increasing demand to also use land for market and export-oriented production (mainly olives and dates), the traditional system will likely change towards larger-scale and commercialised practices. In this regard, Hill and Woodland (2003) suggested combining the modern measures of the large-scale SWC program with traditional practices, an approach that could potentially reduce negative policy effects such as small-scale farmers being neglected by program benefits (see Brismar 2002), causing disadvantages in competiveness.

Our study revealed that SWC-induced `land modifications´ entail changes in socio-environmental functions that are partly perceived negatively by regional stakeholders. At this stage, policy makers have to evaluate the potential trade-offs between policy goals, stakeholder preferences and potential policy risks. It could be argued that modernisation and development will always entail changes in regional traditions. However, it is also the responsibility of decision makers to communicate these potential changes to local stakeholders in order to achieve greater acceptance and fuller implementation of the policy interventions. An importance assessment revealed the potential risk of SWC having unintended effects such as overexploitation of natural resources as a result of overgrazing. Livestock keeping and nomadic pastoralism have a long tradition in southern Tunisia (H.Steinfeld et al. 2010). However, competition between land users and

increasing numbers of livestock have contributed to severe land degradation problems in this region (Jeddi and Chaieb 2010).

3.4.2 Some methodological reflections on the FoPIA methodology

The FoPIA approach was critically evaluated and discussed with the local research team (mainly in terms of methodological potential and limitations) and with the stakeholder group (mainly in terms of the potential utility of the outcome). The quantitative information required for scenario development was derived from the literature, whereas local knowledge was a crucial complement to the implicit information for the regional SWC policy implementation. Similar to a study conducted by Holman et al. (2008), we found that stakeholder participation helped to elaborate policy scenario assumptions and to achieve high acceptance for the scenarios.

The indicator 'development' appeared to be the most challenging because all three dimensions of sustainability had to be considered in its assessment. On the one hand, the stakeholders had different disciplinary backgrounds, and on the other hand, an interdisciplinary set of social, economic and environmental assessment indicators had to be developed in a balanced way that was acceptable to the whole stakeholder group. In particular, the social indicators needed to be extensively discussed because they require a more qualitative type of consideration that, in general, makes them more difficult to capture (see Singh et al. 2009; Slee 2007).

The land use functions helped to ensure a balanced development of indicators and to forge links between the SWC policy, regional land management, and sustainability. Aggregation of the assessment results, also based on the LUF approach, provided an estimate of the contributions of individual scenarios to sustainability, from which implications for regional land management could be drawn. The impact assessment considered those stakeholders who were responsible for the regional planning, support and/or implementation of the SWC policy. The invited stakeholder group (group two) had a strong regional background and was able to follow the assessment procedure. Although an attempt was made to balance the group among disciplines, it appeared that the participants had stronger backgrounds in economic and environmental aspects. The stakeholder group positively rated the opportunity to jointly assess and explore possible SWC consequences in a structured and research-based setting. The opportunity to clarify causal relationships between policy actions and regional sustainability and to reflect on

and learn from discussions and illustrations of assessment results was very much appreciated by the participants. We conclude that FoPIA could be a useful tool, for example, for researchers or consultancies to support the implementation of regional sustainable development strategies.

3.4.3 Implications for regional SWC policy implementation

Based on the assessment results, full implementation of the SWC (SWC-100) could potentially have the highest contribution to sustainability, and implementation at 85% (SWC-85) was predicted to have comparable effects, albeit with less serious negative impacts on ecosystem processes. Considering the fact that the full implementation of SWC measures (SWC-100) also entails negative impacts on the natural system, SWC implementation at 85% might be preferable.

3.5 Conclusions

In this study, we demonstrated how to implement and conduct an impact assessment of alternative SWC policy scenarios in the Oum Zessar watershed, southern Tunisia, using the participatory FoPIA assessment tool. A main outcome of applying FoPIA is the learning process during the assessment procedure. This process raises awareness of the possible consequences of policy decisions in the light of sustainable development while also informing key stakeholders involved in decision making about possible directions for policy improvement. Our study showed a differential impact of SWC scenarios on selected social, economic and environmental land use functions:

The results of the impact assessment showed that the selected social and economic land use functions mainly benefit under the promotion of SWC measures as a result of enhanced water resource availability for land-based production.

The land use functions assessed to be of the highest important by the stakeholders were also targeted by SWC policies, i.e., the provision of abiotic resources (water availability, ENV 1), primary production (ECO 2), and the provision of work (SOC 1).

The LUF `Cultural identity´ was assessed as having a negative impact if SWC measures are expanded due to changes in 'traditional (SCO 3)' landscapes (e.g., introduction of dams, gabions, etc.).

The expansion of SWC measures in the Oum Zessar watershed was assessed to have negative impacts on the natural vegetation (ENV 2) and key ecosystem processes (ENV

3) as a result of changes in land management accompanied by increasing land use pressure.

Based on the assessment results, an implementation of the SWC policy at 100% coverage of manageable land could be suggested if achieving the maximum socio-economic benefit is the goal. However, if stakeholders' preferences are taken into account, and considering the fact that the implementation of SWC measures also implies some negative changes to the natural system, SWC implementation at 85% might be preferable.

From a methodological perspective, the role of stakeholder participation appeared to be crucial during all assessment steps for the consideration of region-specific and implicit information:

- to translate policy measures into a plausible set of regional land management scenarios,
- to analyse the sustainability context and key land use functions,
- to develop operational and regionally relevant assessment indicators,
- to assess and explore SWC scenario impacts and trade-offs, and
- to derive possible suggestions for implications in land management.

We conclude that participatory impact assessment contributes to an enhanced regional understanding of key linkages between policy effects and sustainable development. On the one hand, stakeholder knowledge was used to provide a region-specific and holistic picture of the potential impacts of policy on sustainable development. On the other hand, in addition to providing their knowledge; the stakeholders also benefited from the impact assessment process. Land administrators and authorities have an interest in successful and efficient policy implementation. Active participation during the impact assessment provides a platform for social learning, exchange and better understanding of the complexity of human-nature interactions. We believe that a better understanding of this complexity will translate into sustainable and efficient policy implementation at the regional level.

Chapter 4

Assessing the impact of the Sloping Land Conversion Programme on rural sustainability in Guyuan, Western China

Abstract

The goal of China's sloping land conversion programme (SLCP) is to combat soil erosion and to reduce rural poverty. An ex-ante assessment of possible SLCP impacts was conducted with a focus on rural sustainability, taking the drought-prone region of Guyuan in Western China as an example. The Framework for Participatory Impact Assessment (FoPIA) was used to conduct two complementary impact assessments, one assessing SLCP impacts at regional level and a second one assessing alternative forest management options, to explore possible trade-offs among the economic, social and environmental dimensions of sustainability. Regional stakeholders assessed the SLCP to be capable of reducing soil erosion but felt it negatively affected rural employment, and a further continuation of the Programme was advocated. Assessment of three forest management scenarios by scientists showed that an orientation towards energy forests is potentially beneficial to all three sustainability dimensions. Ecological forests had disproportionate positive impacts on environmental functions and adverse impact on the other two sustainability dimensions. Economic forests were assessed to serve primarily the economic and social sustainability dimensions, while environmental impacts were still tolerable. The FoPIA results were evaluated against the available literature on the SLCP. Overall, the assessment results appeared to be reasonable, but the results of the regional stakeholders appeared to be too optimistic compared with the more critical assessment of the scientists. The SLCP seems to have the potential to tackle soil erosion but requires integrated forest management to minimize the risk of water stress while contributing to economic and social benefits in Guyuan.

4.1 Introduction

The remote and less developed region of Guyuan in western China is threatened by vast soil erosion and land degradation problems due to fragile soils, droughts and increasing consumption of natural resources by a growing population. The impact of land conversion programs on rural sustainability in such an area of conflict are of particular interest, to avoid a further worsening of undesired development trends.

In 1999, the Chinese government initiated the nationwide Sloping Land Conversion Program (SLCP), also known as the "Grain for Green Project" to tackle this problem (Xu et al. 2004). The program was implemented by converting crop production on erosion prone land with steep slopes into forests and grassland in large parts of the upper Yellow and the Yangtze River basins (Xu et al. 2006). Besides having the major goal of reducing

land degradation the SLCP also aimed at alleviating rural poverty and at stimulating economic development in rural regions (Bennett 2008; Grosjean and Kontoleon 2009). Cropland on slopes steeper than 25 degrees was suggested to be converted into 'ecological forests' (with primary ecological functions) and grassland while cropland on slopes between 15 and 25 degrees was suggested to be converted into 'economic forests' or grassland including fruit orchards and timber plantations (Weyerhaeuser et al. 2005; Ye et al. 2003). Between the period of 2000 and 2009, 4.8 per cent of cropland has been converted into forest land in Guyuan, according to regional experts. Between 2010 and 2016, additional 3.4 per cent of cropland will be retired for afforestation purposes.

Farmers affected by the program are supposed to receive compensation as cash (300 Yuan per ha) and grains (1500 kg per ha) (Bennett 2008). Financial compensation is provided depending on the type of conversion; two years for conversion into grassland, five years for conversion into economic forests, and maximum eight years for conversion into ecological forests.

The SLCP has widely been recognized of being effective in terms of land conversion efforts with a total size of 146 thousand square kilometres of cropland being converted at national level between 1999 and 2010 (Yin and Yin 2010). Several studies attempted to evaluate the SLCP, for example, related to food security issues (e.g., Feng et al. 2005; Peng et al. 2007; Xu et al. 2006; Yang 2004), soil properties (e.g., Cao et al. 2007; Chen et al. 2007b; Zhang et al. 2010), water balance (e.g., Chen et al. 2007a; Gates et al. 2011; Huang and Pang 2011; Sun et al. 2006) as well as aspects of program implementation, participation and effectiveness (e.g., Bennett 2008; Uchida et al. 2007; Xu et al. 2004; Yin and Yin 2010). In summary, most available SLCP impact studies aimed at economic and social aspects while few studies investigated environmental impacts (this might be reasonable since quantitative data of related to forest ecological require long-term monitoring systems). However, none of these studies have integrated all dimensions of sustainability yet, while equally considering the ex-ante impacts of the SLCP at aggregated level.

In this study an attempt is made to complement regional stakeholder knowledge with scientific expertise in order to conduct a more comprehensible and reflected impact assessment study. Stakeholder participation in environmental studies can be used, for example, to integrate local knowledge (Stringer and Reed 2007; Vogt, V et al. 2011) and to consider different perceptions of stakeholders (Reed et al. 2007; Schwilch et al. 2011).

A previous study of König (2010) explored possible contributions of alternative forest management scenarios to regional sustainability. The study had an isolated view on the forestry sector, while the focus is on impacts of different SLCP implementation options (conversion of cropland into forests) on regional sustainability covering all land use sectors. Findings from König (2010) are picked up to study the regional impacts of the SLCP implementation as well as possible consequences of alternative forest management. Subsequently, results from both assessments are discussed in a complementary way. The aim of this study therefore was to conduct a comprehensive ex-ante impact assessment of the SLCP covering the economic, social and environmental dimensions of sustainability. The results of FoPIA were evaluated under consideration of the available scientific literature on the SLCP reviewed.

4.2 Materials and methods

4.2.1 Study area

The case study region Guyuan is located in the center of the Loess Plateau and refers to the southern part of the Hui autonomous region of Ningxia (Figure 4.1). The main regional problems are harsh environmental conditions, land degradation and low economic development (Zhen et al. 2009a; Zhu et al. 1986). The climate is semi-arid with cold, dry winters and hot, wet summers. The average annual rainfall is 470 mm with regional variability. The terrain is mountainous with elevations ranging from 1,248 m to 2,942 m.a.s.l.

The main land use activities are small holder subsistence agriculture and livestock husbandry with an average farm size of 4.6 mu (15 mu = 1 ha) per family household. In 2009, the rural farm household activities were constituted of 61 per cent of on-farm activities, such as cropping (50 per cent) and livestock breeding (11 per cent), off-farm work (37 per cent) and other activities (2 per cent). Agriculture is rainfed and the major crops include maize, wheat, potato, millet, oilseeds and several legume species (Zhen et al. 2009a). The livestock encompasses sheep, goats, beef cattle, dairy cows, pigs and poultry. The remaining natural vegetation includes wild grassland and shrubs that grow mainly on the steep slopes where human activities were restricted (Chen et al. 2001).

Poor economic development is considered a major constraint for development in Guyuan indicated by low GDP per capita at 8470 RMB which is only 29 per cent of the Chinese national average of RMB 29992 in 2010. The average income of rural household was

RMB 3477 which is 59 per cent of the national average of RMB 5919 in 2010. With the SLCP, Guyuan follows a model centered on environmental priority where economic development comes only as second goal (Zhen et al. 2009b).
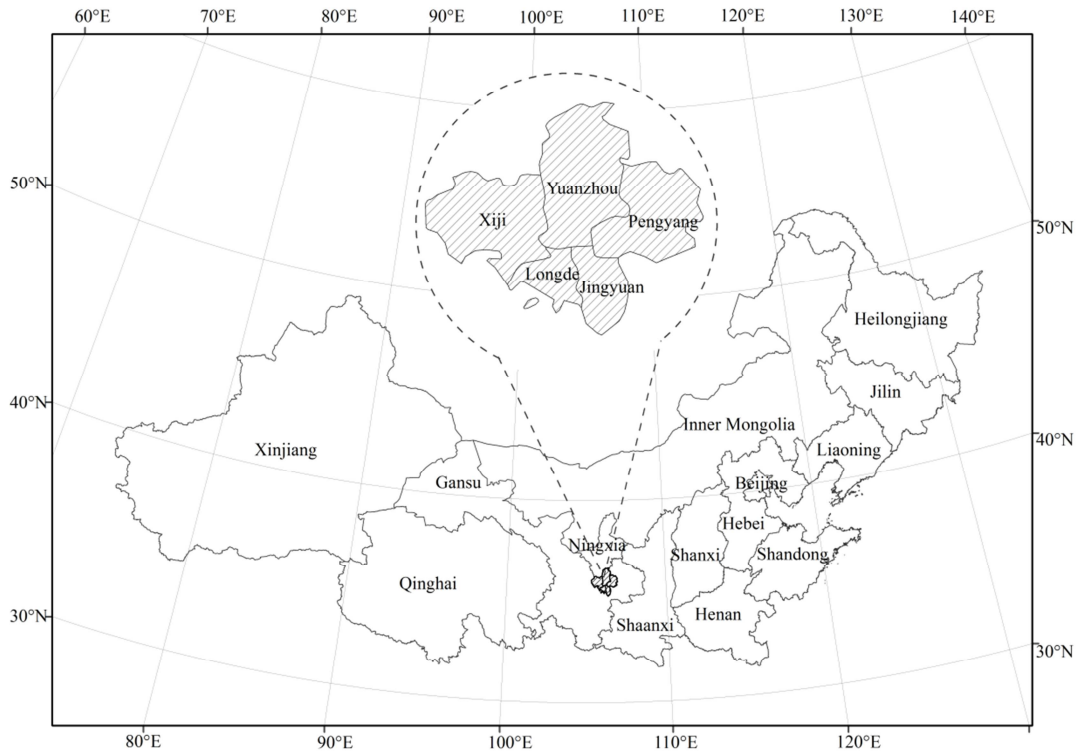
Figure 4.1. Location map of the study area of Guyuan, China.

4.2.2 General impact assessment approach

An approach for structuring the impact assessment of land use changes while equally covering the three sustainability dimensions (economic, social, environmental) is proposed in Helming et al. (2011a) making use of so-called Land Use Functions (LUFs) as developed by Pérez-Soba et al. (2008). This framework appeared to be suitable for Guyuan and was therefore adopted for this study, but it appeared to be challenging to quantify the impact of alternative land use scenarios, such as land conversion as in the case of the SLCP, on the LUFs. Ideally, impacts on LUFs would be derived from a combination of (i) ex-post analysis of monitoring data, (ii) ex-ante simulation experiments, for example, as in the case of the Sustainability Impact Assessment Tool (SIAT) (Sieber et al. 2008) and (iii) participatory expert-based tools (Morris et al. 2011) to also consider stakeholder perceptions and expert knowledge. A thorough literature survey should accompany all three steps to ensure their up-to-dateness and allow for validation.

However, as in many cases in developing and transition countries, lack of data prevented the first two types of analysis in Guyuan. Area-wide, spatially-explicit monitoring data of the SLCP implementation in Guyuan did not exist. Some inofficial paper-based reports existed, but their reliability is unclear, reporting high tree survival rates of 80 to 90 per cent. Personnel from the responsible government agencies disclosed that dead trees were simply replaced by new seedlings, without actually reporting this. Field visits were limited to demonstration sites and therefore not representative. Other studies circumvented such conditions by surveying SLCP participants (see, for example, Uchida et al. 2005; Xu et al. 2004; Yang 2004). Participants' answers are a common source of information but their reliability is unclear, particularly since farmers usually have a sector specific view and are often less well educated, therefore less likely to be capable of performing sustainability assessments, and involuntary participation is a frequently observed phenomenon (Grosjean and Kontoleon 2009).

4.2.3 The FoPIA approach

To assess program effects at an aggregated regional scale, it appeared to be more promising to take the road of a participatory expert based approach to analysis, by making use of the Framework for Participatory Impact Assessment (FoPIA) (Morris et al. 2011). FoPIA comprises a preparation phase and an expert workshop, that follows a structured sequence of assessment steps, including (i) interactive development of regional land use scenarios, (ii) specification of the sustainability context, and (iii) expert-based assessment of scenario impacts and analysis of possible trade-offs among the economic, social and environmental sustainability dimensions. An after-workshop evaluation phase is used to further analyse and document workshop results.

The approach benefits from a diverse group composition, as only then a variety of different views can be considered, but group diversity also adversely affects scenario complexity. For example, a heterogeneous group can usually handle relatively simple scenarios as only then the group members will feel capable of assessing them. On the other hand, due to the variety of views considered, an aggregated assessment, for example, at the level of sustainability, is more likely to achieve with such a group. In contrast, a more homogenous group, for example, experts in one field, will be able to deal with complex scenario assumptions; results, however, will likely remain at the level of

the disciplines involved and therefore not allow for overall conclusions at the level of sustainability.

Under consideration of this aspect, we decided to follow a two-step approach. A first FoPIA workshop was held in 2009 in Guyuan with a heterogeneous group of regional experts SLCP (from now on referred to as "regional group") to assess the impact of SLCP land conversion on sustainability at regional level, using relatively simple scenario assumptions. A second FoPIA workshop was held at the Chinese Academy of Science in Beijing in 2010 with a relatively homogenous group of scientists from different national research institutes to assess the impact of more complex scenarios focusing on alternative SLCP forest management options (from now on referred to as "forest group"). Work from the second workshop has been published in a previous article by König (2010) but this study had an isolated view on the forestry sector and did not consider SLCP impacts on regional sustainability.

4.2.4 Workshop participants

The regional group was directly consulted in Guyuan and included ten experts from the Bureau of Environmental Protection, Development and Reform Commission, Guyuan Agriculture Research Institute, Bureau of Forestry, Department of Regional Water Management, Bureau of Agriculture and Animal Husbandry and Bureau of Land Resource Management. The workshop was part of a longer field trip and accompanied by a household survey in three villages and a participatory rural appraisal in one village.

For the forest group, ten researchers with a specific knowledge about the regional conditions in Guyuan and specific expertise in the SLCP were invited to participate in an expert workshop, including scientists from the Chinese Academy of Forestry (CAF), the Department of Natural Geography (IGSNRR, CAS), the Department of Human Geography (IGSNRR, CAS), the Department of Natural Resources and Environmental Security (IGSNRR, CAS) and the Chinese Academy of Social Sciences (CASS).

4.2.5 Expert-developed scenarios

Scenario narratives were drafted by the research team, based on available data and figures, and presented to the regional group and the forest group for discussion, respectively. Scenario assumptions were elaborated together with the group participants considering implicit knowledge and to ensure a commonly understood and accepted set of

scenarios (Table 4.1). In the regional group three scenarios were assessed, including two SLCP implementation scenarios (first phase of the implementation between 2000 and 2009 (S2), and a second implementation phase between 2010 and 2016 (S3) and a reference scenario (S1) that served as a counterfactual to assess impacts in the absence of the SLCP (continuation of crop production) (Table 4.1). The forest group assessed the impact of three alternative forest management scenarios, including an economic-forest (F1), an ecological-forest (F2) and an energy forest management (F3) scenario (Table 4.1). Land use sectors included agriculture, forestry and built-up areas. The target year of all scenarios was 2020. Both workshops started with the introduction of a drafted set of scenario narratives which were presented to the corresponding workshop participants.

Table 4.1. SLCP implementation scenarios (S1, S2, S3) and forest scenarios (F1, F2, F3).

Scenario	Scenario characteristics	Land use sectors	Relevance to Guyuan
S1 (REF)	Forest cover at 12.8%. Remaining land mainly used for agriculture production	All sectors	Reference scenario as without SLCP policy implementation
S2: SLCP-1	Conversion of cropland into forest land on slopes above 25°; forest cover increases by 4.8% to 17.6%	All sectors	SLCP implementation between 2000 and 2009
S3: SLCP-2	Conversion of cropland into forest land on slopes between 15° - 25°; forest cover increases by additional 3.4% to 21%	All sectors	Further expansion of the SLCP between 2010-2016
F1: economic forest	Orchards for fruit plantations (apple, nuts, apricot etc.)	Forest sector	Partially established agro-forest type at 20-25%
F2: ecological forest	Planting and maintaining trees with limited economic use to restore degraded land	Forest sector	Main forest type established under the SLCP at 70-80% in Guyuan
F3: energy forest	Use of sloped and marginal land for energy production	Forest sector	Little recognition yet of less than 1%

Note: SLCP, Sloping Land Conversion Program; REF, reference scenario.

4.2.6 Expert-based impact assessment

A set of nine Land Use Functions (LUFs) and nine Forest Functions (FFs) had been developed prior to the workshop, taking the general set of LUFs from Pérez-Soba et al. (2008) as starting point and under consideration of the results from the PRA in Guyuan, and were introduced to the regional group and the forest group, respectively (Table 4.2). Both sets of functions were equally balanced among the economic, social and environmental sustainability dimensions. Together with the workshop participants, each function was assigned one corresponding indicator in order to have a precise criterion for the impact assessment, for example, regional employment rate for the provision of work or water availability for the provision of abiotic resources (Table 4.2). We decided to have only one indicator per function in order to avoid complexity and to keep the scenario assessment focused and operational during the assessment workshops.

Subsequently, experts passed two paper-based assessment rounds on each workshop; one for assigning weights from one to nine to the different LUFs, reflecting their perceived importance, and one for assessing the impact of the different scenarios on the LUFs using a scale from -3 to +3. After each round, the assessment results were projected, discussed and re-scoring was allowed as needed, to reduce the range of assessment results. For further reading on each step of FoPIA, we refer to Morris et al. (2011).

The assessment of the scenarios for the three sustainability dimensions is based on an aggregation of the scenario impact scores and corresponding LUF and FF weights by using the following equation:

$$wi_d = \sum_{f=1}^{n} w_{f,d} * i_{f,d} \qquad (1)$$

Where: wi=weighted impact, w=weight assigned to each function, i=average impact for each function, d=sustainability dimension (economic, social, environmental), f=function (n = 9).

This allows for comparison of different scenarios and a ranking of scenarios, based on which, possible implications for land use and decision support can be discussed.

4.2.7 Literature survey of SLCP impact studies

A literature survey of SLCP impact studies was conducted on the basis of scientific databases including SCOPUS and ISI Web of Knowledge. Key words including "sloping land

conversion program" and "grain for green program" were combined with topics related to the nine Land Use Functions and nine Forest Functions (Table 4.2) and resulted into a list of 39 publications covering the relevant topics (Table 4.3). Although we are aware that much has been published in the Chinese literature we were only capable to consider articles published in the English literature.

4.3 Results and Discussion

4.3.1 Relative importance of Land Use Functions

In the regional group, the economic LUF land based production (8.5) was assessed to be of highest priority, as it was considered to be the major economic activity of rural people in Guyuan (Table 4.2). Of slightly lower importance were the environmental LUFs maintenance of ecosystem processes (7.5) and provision of biotic resources, (7.6) reflecting the regional vulnerability of the environment in Guyuan, prone to land degradation and losses in biodiversity. The lowest weights were assigned to the LUF non-land based production (6.0) reflecting that most of the rural society in Guyuan is still employed in the agricultural sector and that opportunities for non-land based production in this remote region are limited. The LUFs food security (7.1) and quality of life (7.0) were reported to be two major concerns for rural farmers in Guyuan, as agricultural production and rural livelihood were frequently affected by droughts, loss of harvests, and rural poverty, respectively, and therefore received high scores. The provision of abiotic resources (6.5) related to soil was perceived to be a critical factor for land based production but relatively less important than other functions. This may appear contradictory, as the SLCP has a particular focus on this aspect, but reflects that the workshop participants applied a kind of "fairness" principle when comparing different functions. Of relatively lowest importance were the LUFs provision of work (6.1) and infrastructure (6.1).

4.3.2 Relative importance of Forest Functions

In the forest group, all environmental functions were given high weights reflecting the need to reduce land degradation in Guyuan with abiotic resources (8.7), biotic resources (7.7), maintenance of ecosystem processes (9.7) (Table 4.2). The economic function income from wood production (6.0) was assessed to be of lowest importance compared to other FFs. Wood production was expected to be low as tree growth will be slow due to

high elevations and chronic water shortages. Instead, participants stated that alternative sources related to income from non-wood products (8.0), for example fruit production, play a more important role. Income from forest services and processing industry (7.7) referring to maintenance activities and forest management were assessed of higher importance. The social FFs including the provision of forest labour (6.7) was considered to be of relatively low importance due to little working opportunities in the forest sector in general as the programme mainly aims to establish ecological forests (restricted use). Health (7.3), in this case related to clean (dust-free) air, was considered to be of high importance since frequently occurring dust storm harm human health of local people. Access to forests (7.0) was also perceived important for collecting fuel wood.

Table 4.2. Land use functions, forest functions and corresponding assessment indicators.

Land use functions (LUFs)	LUF-indicator
ECO 1: Land based production	Economic production from land [yield]
ECO 2: Non-land based production	Built-up area [m³]
ECO 3: Infrastructure	Road density and quality [length and status]
SOC 1: Provision of work	Regional employment [%]
SOC 2: Quality of life	Net income per household [RMB]
SOC 3: Food security	Regional food availability [kg/capita]
ENV 1: Abiotic resources	Soil health/quality [status]
ENV 2: Biotic resources	Habitat and biodiversity [status]
ENV 3: Ecosystem processes	Vegetation cover [status]
Forest functions (FFs)	*FF-indicator*
ECO 1: Wood production	Income from wood harvests [RMB]
ECO 2: Non-wood production	Income from fruit yields [RMB]
ECO 3: Industry and services	Income from forest industry and services [RMB]
SOC 1: Forest labour	Sectoral employment [%]
SOC 2: Health	Clean air [status]
SOC 3: Access to land	Right to access and utilize forest
ENV 1: Abiotic resources	Soil health/quality [status]
ENV 2: Biotic resources	Habitat and biodiversity [status]
ENV 3: Ecosystem processes	Water availability/yield [m3]

Note: ECO, economic; SOC, social; ENV, environmental. Forest functions and corresponding indicators.

4.3.3 Land Use Functions and Forest Functions addressed in the literature

Analysis of the literature revealed differences in topics of available impact studies (n=40). As shown in Table 4.3, most studies have focused on economic and social impacts of the SLCP and were mainly related to agriculture (land based production, n=26; income,

n=16; and work, n=13). With regard to forest management, fewer studies were available and were looking at economic wood production (n=8) and forest industry and services (n=8) while non-wood production (i.e. fruit production) were only partly addressed (n=6). Only few studies were addressing social issues related to forest labor sector (n=4), health (n=4), and the role of land rights (n=4). Environmental studies have mainly addressed soil and water conservation issues (n=13) and related issues to ecosystem processes (n=15). Infrastructure (n=3) and biodiversity (n=4) were usually only mentioned but not part of the analysis.

Topics which were less often addressed in the literature though of relatively high importance to the regional group and to the forest group included biodiversity and non-wood production, respectively.

Table 4.3. Overview of land use functions (LUFs) and forest functions (FFs) covered by the impact studies (LUFs and FFs explanations can be found in Table 4.2)

Authors	Year	Economic LUFs			Economic FFs			Social LUFs			Social FFs			Environmental LUFs/FFs		
		ECO1	ECO2	ECO3	ECO1	ECO2	ECO3	SOC1	SOC2	SOC3	SOC1	SOC2	SOC3	ENV1	ENV2	ENV3
Ye et al.	2003	x									x					
Xu et al.	2004	(x)													(x)	
Hong	2004												x			
Feng et al.	2005	x								x						
Uchida et al.	2005	x	x					x	x							
Weyerhaeuser et al.	2005				x	x	x	x	x		x					
Chen and Cai	2006				x		x							x		x
Edinger and Huafang	2006	x						x	x							
Long et al.	2006	x							x					x		
Sun et al.	2006	x														x
Xu et al.	2006	x	x		x	x		x	x							
Xu et al.	2006	x					x									
Zheng	2006													x		x
Cao et al.	2007				x		x					x		x		x
Chen et al.	2007	x												x		x
Chen et al.	2007	x			x									x		x
McVicar et al.	2007	x														
Peng et al.	2007	x					x		x	x						
Uchida et al.	2007	(x)						x	x							
Wang et al.	2007	x					x	x	x		x					
Bennett*	2008															
Cao	2008	x			x							x		x		x
Wang et al.	2008	x				x						x		x		x
Zhang et a.	2008	x												x		x
Cao et al.	2009	x		(x)	x		x	x	x			x		x		x
Grosjean and Kontoleon	2009	x			x		x	x	x				(x)			
He et al.	2009	x				x										
Stokes et al.	2009	x		(x)				x			x			x		
Uchida et al.	2009		x					x	x							
Chen et al.	2009	x	x	(x)				x	x						(x)	
Dai	2010	x														
Liu et al.	2010	x			x	x		x	x							
Wang et al.	2010	x	x		x			x	x							
Yang et al.	2010													x	(x)	
Yao et al.	2010	x	x					x	x							
Zhang et al.	2010				x		x	x	x					x		
Bennett et al.	2011				x	x	x	x	x				(x)			
Cao et al.	2011	x			x	x						x		x		x
Gates et al.	2011	x														x
Huang and Pang	2011	x				x								x		x
LUFs and FFs addressed	(n)	26	6	3	8	6	8	13	16	4	4	4	4	13	4	15

Note: Topics that are only partly addressed and not explicitly directed to the SLCP are indicated by (x).

4.3.4 Assessment of the economic dimension

Land based production and wood production (ECO1)

The regional group assessed the conversion from cropland into forest towards 2020 to increase the overall economic production from land in Guyuan (S2, S3) compared to the reference situation of continued crop production (S1) (Table 4.4). The forest group assessed the potential economic benefits from wood production to be positive under economic forests (F1), but to perform negatively under ecological forests (F2) and limited with energy forests (F3) (Table 4.4). The quite different perception in the regional group that afforestation would contribute to economic development was based on the assumption that planting forests would generally maximize the economic use of marginal land.

Wood production does not play a considerable role in Guyuan as unfavourable environmental growing conditions (water scarcity, high elevations) limit commercial forestry in this region (Cao et al. 2009a). Economic returns from energy forests (F3) were assessed to provide some benefits but this type of forest management has not been established in Guyuan yet and might therefore only be realized at small-scale. In this regard, Tang et al. (2010) mentioned the potential of growing shrubs for energy production on less productive sites.

Non-land based production and non-wood production (ECO2)

The regional group expected the SLCP to stimulate non-land based development (expansion of built-up areas) (S2, S3) (Table 4.4) based on the assumption that the SLCP will contribute to rural economic development through structural changes. However, this aspect might be difficult to be attributed directly to the programme since high economic development at national level has pushed construction activities in China (Zhen et al. 2010).

With regard to non-wood production, the two main limiting factors to plant economically attractive trees (mainly fruit trees) are water scarcity and management skills. Although about 20 per cent of the afforested land in Guyuan is dedicated to economic forests (F1), a major concern mentioned by workshop participants was that farmers might not have sufficient knowledge for actually managing forests and lack technical equipment for maintenance and harvesting. The issue of insufficiently skilled labour forces in the

growing forest sector is also addressed by Weyerhaeuser et al. (2005). Several studies found that farmers would favour to convert land into economic forests (for example, Weyerhaeuser et al. 2005; Yang 2004; Ye et al. 2003) but the decision of tree selection (and provision) is usually taken by the local governments (Bennett et al. 2011).

Infrastructure and (forest) industry and services (ECO3)

Similar to the results of non-land based production (ECO2) infrastructure (ECO3) development was assessed to benefit under the SLCP (S2, S3) (Table 4.4), assuming that the programme will lead to higher investments into road construction projects in Guyuan. However, there is no evidence to prove this result although some other SLCP studies addressed the negative impact of roads on soils (compaction, erosion) in general (Chen et al. 2009; Stokes et al. 2010) but without explicit link to the SLCP.

In the forest group, both, economic and energy forests (F1, F3) were assessed to develop (forest) industry and service sector, including the processing of fruits (packing, selling) and the provision and installation of energy systems (e.g., small energy plants, stoves). Besides some cultivated fruit trees (e.g., Nuts, Apricot, Apple), cultivation and processing of Wolfberry (Lycium chinense) is considered a major economic fruit-shrub in Guyuan which is well suited to grow under dry conditions (Mi et al. 2011). Most afforestation sites are restricted to grow economic valuable fruit trees at larger scales and thus limit the establishment of fruit processing industry. Since forest work is usually done by man-power, forest services will likely be required to manage and maintain forest land (e.g., planting, thinning, pruning, harvesting).

4.3.5 Assessment of the social dimension

Provision of work and forest labour (SOC1)

The most negative impact of the SLCP in Guyuan assessed by the regional and the forest group, respectively, referred to a reduction of work (S2, S3, F2) (Table 4.4), worsened by the limited flexibility to leave the farm (lack of mobility and low education). During field interviews, local farmers reported that the older generation of farmers, in particular, had difficulties in adapting to such changes relying on governmental support more than younger generations (see also Uchida et al., (2009)). The potential contribution of afforested land to provide rural work will be limited in the future since economic forests (F1) play a minor role in Guyuan. Chen et al. (2009) argues that releasing labour forces

from agriculture could stimulate a shift towards off-farm work. However, a regional study of Uchida (2007) conducted in Ningxia (a province to which Guyuan belongs) found little evidence for participating farm households shifting labour to alternative off-farm activities due to mobility constraints and actually preferring to stay at the farm.

Quality of life (income) and health (SOC2)

Changes in rural income towards 2020 were assessed to increase under the implementation of the SLCP (S2, S3; Table 4.4) as a result of increasing income generated from fruit harvest from planted trees and contributing to shift agricultural activities towards the off-farm sector. The increasing importance of the off-farm sector for generating rural income has also been found by several other impact studies (for example, Ediger and Chen 2006; Liu et al. 2010; Yao et al. 2010). Following the major goal to combat soil erosion, all forest management scenarios (F1-3, Table 4.4) revealed that wind erosion and dust pollution will likely be reduced, an important health aspect for rural people in Guyuan. Several studies reported on the success of revegetating hillslopes reducing soil erosion (see for example, Chen and Cai 2006; Stokes et al. 2010; Zheng 2006) other authors questioned this aspect with particular reference to semi-arid regions of the Loess Plateau, referring to high tree mortality rates, and thus failure of establishing permanent soil cover (Cao et al. 2007; Chen et al. 2007c).

Food security and access to forests (SOC3)

Food security has long been a concern in rural China and particular attention was paid under the circumstances that cropland will be converted into forests and grassland. However, the regional group was optimistic by positively assessing the SLCP to contribute to an improved situation of food availability in Guyuan (Table 4.4), based on the assumption that only marginal land will be taken out of production. Studies by Yang (2004) and Dai (2010), however, found that some of the farmers enrolled in the programme were able to increase production on the remaining land. Several other studies explicitly analysed the programme's effects on food security (for example, Feng et al. 2005; Peng et al. 2007; Xu et al. 2006; Zhen et al. 2009a). Feng et al. (2005) indicated that food security in Western China might be more important than in other regions in China as a result of supply constraints; and that, although national food security might not be affected at national level, local impacts could be significant. However, a recent study by Zhen et al. (2009a) found that increasing meat consumption of people in Guyuan

indicates changes in the diets of rural people that might affect increasing demands on grain supply in the future.

The right to access forests to collect fuelwood was assessed positively by the forest group for all scenarios (F1-3). Comparable studies explicitly addressing this issue do not exist however; it is known that land per se does not belong to the farmer himself.

4.3.6 Assessment of the environmental dimension

Environmental functions were not differentiated between regional land use and the forest sector as they both cover relevant environmental functions.

Provision of abiotic resources (ENV1)

All SLCP scenarios (S2, S3, F1-3; Table 4.4) were assessed to improve the soil quality in Guyuan through afforestation by the regional group and the forest group. The common assumption was that revegetating eroded land with trees will reduce soil erosion. It is widely accepted that vegetation cover is a means to control soil erosion (Zheng 2006). Cao et al. (2008), however, pointed at the risk of large-scale afforestation might leading to higher soil erosion problems in the long run as a result of using fast growing tree species (e.g., Pine, Locust, Poplar), instead of using natural vegetation (e.g., shrubs, Birch, Oak) leading to water stress and tree mortality, while Yang et al. (2010) stressed the challenge of the low resilience in semi-arid regions of the Loess Plateau and supported the need to plant trees and establish grassland for a timely recovery of degraded soils. The debate included aspects of whether native species should be considered.

Provision of biotic resources (ENV2)

Afforestation and forest management were both assessed to improve the quality of habitats and increase biodiversity of regional flora and fauna. Having in mind that Guyuan is dominated by agriculture forests will contribute to higher landscape diversity. While this seems generally plausible, Cao et al. (2009a) pointed at the risk that the programme induced introduction of non-native species might harm the existence of native species. An empirical study explicitly addressing the impact of the SLCP on habitat quality and biodiversity has not been conducted yet.

Maintenance of ecosystem processes (ENV3)

Apart from economic forests (F1), the SLCP scenarios (S2, S3) and forest management scenarios F2 and F3 (Table 4.4) were assessed to enhance key ecosystem processes in Guyuan. However, both groups might have overestimated the positive effect of ecological forests. Among the main tree species established in Guyuan, pine forests (Pinus spec.) were found to contribute to the highest water losses due to high surface runoff (assuming that ground vegetation is missing) followed by cropland, grassland and shrubland (Chen et al. 2007a). In the long run, tree mortality problems due to water stress might also occur for two other tree species used for afforestation purposes, including Locust (Robinia spec.) and Poplar (Populus spec.) (Fischer 2010). In this regard, Sun et al. (2006) points at the potential reduction in water yields caused by planted trees in the semi-arid north of China where naturally grassland, shrubs and small trees grow (Cao et al. 2011). Instead, Cao et al. (2011) put forward the need to orient at 'close-to-nature' species (native and regionally well adapted species) which could improve and sustain forest quality in the longer term.

4.3.7 Assessment of regional SLCP impacts: an integrated view

Aggregation of impacts (Table 4.4) allows for a weighted interpretation of SLCP scenario impacts at regional context. If first looking at the implementation scenarios of the SLCP in Guyuan (S2, S3) the main trade-offs occur between provision of work (SOC1) and the conservation of environmental functions (ENV1-3). Without the SLCP (S1, crop production), particularly the environmental (ENV1-3) and partly also the social dimension (SCO1 and 3) were assessed to face a continuing negative development in Guyuan, while the main positive impacts of the SLCP are clearly on the environmental dimension, which was also of high priority as reflected in the weights assigned to the Land Use Functions (Table 4.4). The results suggest that an expansion of the SLCP (S3) would contribute most to sustainable development in Guyuan towards 2020.

In the case of regional forest management, trade-offs vary among scenarios (F1-3) (Table 4.4). Economic forest (F1), for example, has the highest positive impact on all economic functions (ECO1-3) and some social functions (SOC1 and 3) but negative impact on the regional water balance (ENV3). Ecological forest (F2) contributes to the highest benefit of all environmental functions (ENV1-3) but was assessed negative for wood production (ECO1) and provision of work (SOC1). Energy forest (F3) was assessed to have little, but

overall positive impact on all nine forest functions. The results suggest, firstly, considering the possibility of establishing energy forests (F3) which might be a promising alternative to contribute to farm households and environmental conservation at the same time (small-scale). Secondly, an integration of ecological and economic forests (F1, F3) at large-scale could potentially lower the mentioned trade-offs but would require adequate long-term forest management strategies.

Table 4.4. Scenario impact assessment results on regional land use functions and forest functions (explanations of corresponding functions can be found in Table 4.2).

Scenario	ECO 1		ECO 2		ECO 3		SOC 1		SOC 2		SOC 3		ENV 1		ENV 2		ENV 3		aggregated impact			
	w	i	w	i	w	i	w	i	w	i	w	i	w	i	w	i	w	i	w_{ECO}	w_{SOC}	w_{ENV}	w_i
S1 (REF/crop)		0,4		0,7		1,0		-0,4		-1,0		0,1		-0,8		-1,9		-1,0	13,7	-8,7	-27,1	-22,2
S2 (SLCP 1)	8,5	1,4	6,0	1,0	6,1	1,0	6,1	-0,4	7,0	1,7	7,1	1,4	6,5	1,4	7,6	1,8	7,5	1,7	24,0	19,4	35,5	78,9
S3 (SLCP 2)		1,7		1,4		1,6		-1,1		2,2		2,1		2,4		2,8		2,8	32,6	23,6	57,9	114,1
F1 (economic)		0,8		2,8		2,3		2,3		1,8		2,5		0,4		0,5		-0,4	16,9	17,3	1,4	94,4
F2 (ecological)	6,0	-0,9	8,0	0,3	7,7	0,1	6,7	-0,8	7,3	3,0	7,0	0,3	8,7	2,7	7,7	2,8	9,7	2,5	-0,6	7,2	18,7	85,7
F3 (energy)		0,8		1,4		1,5		0,1		1,4		1,6		0,7		1,5		1,1	10,3	7,7	7,3	78,0

Note: wi, weighted impact; w, weight assigned to each function; i, average impact for each function; d, sustainability dimension (economic, social, environmental); f, function (n = 9). Results of the forest scenario assessment (F1–3) are adapted from König (2010).

73

4.3.8 Reflection on the assessment approach

The participatory impact assessment approach used has the potential to reveal possible trade-offs between economic, social and environmental sustainability dimensions that might occur as a result of the SLCP land conversion programme in Guyuan. In reflection to previous studies where FoPIA was used (for example in Indonesia, König et al. 2010), we found that this participatory approach provides a flexible but well-structured framework to study causal relationships between policies, land use changes and sustainability while also integrating local knowledge of different disciplines. Participating experts (scientists) and stakeholders (regional decision makers) reported that FoPIA is relatively easy to understand and appreciated that this approach provides quick results. However, the quality of the results largely depends on the scenarios developed, indicators selected and stakeholders considered. For example, during the expert-based impact assessment, the regional group appeared to be very optimistic about possible SLCP impacts, while the forest group was more critical about programme effects. Although the regional group might have been biased of being in favour of the SLCP, their participation and knowledge contributed to an enhanced understanding of the regional problem issues and the implementation of the SLCP in Guyuan.

4.4 Conclusions

A clear win-win scenario leading to positive developments for all Land Use Functions or Forest Functions, respectively, could not be identified. Both groups of the participatory impact assessments (the regional group and the forest group) expected the SLCP programme to achieve the major goal of environmental rehabilitation but at the cost of reducing rural working opportunities, since ecological forests alone provide only few employment and income opportunities beyond the project's life time. Overall, based on the assigned priorities, a continuation of the SLCP afforestation appeared to be most beneficial from all scenarios for rural sustainability in Guyuan. The economic forest scenario was assessed to serve primarily the economic and social sustainability dimensions, while environmental impacts were also tolerable. Energy forest is potentially benefiting all three sustainability dimensions (economic, social, environmental) but might only be realized at small scale since this type of forest management is not well established in Guyuan yet. A scenario with a sole focus on ecological forests had a disproportionate positive impacts on environmental functions and little or adverse impact on the other two

sustainability dimensions. Considering that Guyuan is a drought-prone region, long-term failures of afforestation might occur due to water stress and the use of water demanding tree species. Forest managers, therefore, might reconsider the choice of planting more shrubs or native tree species for the second implementation phase of the SLCP. Finally, we conclude that the here proposed assessment approach using both qualitative knowledge and quantitative information, could enhance the understanding of regional causal linkages between the SLCP land conversion programme and possible impacts on economic, social and environmental sustainability dimensions.

Chapter 5

Regional impact assessment of land use scenarios in developing countries using the FoPIA approach: findings from five case studies

Abstract

The impact of land use changes on sustainable development is of increasing interest in many regions of the world. This study aimed to test the transferability of the Framework for Participatory Impact Assessment (FoPIA), which was originally developed in the European context, to developing countries, in which lack of data often prevents the use of data-driven impact assessment methods. The core aspect of FoPIA is the stakeholder-based assessment of alternative land use scenarios. Scenario impacts on regional sustainability are assessed by using a set of nine regional land use functions (LUFs), which equally cover the economic, social and environmental dimensions of sustainability. The cases analysed in this study include (1) the alternative spatial planning policies around the Merapi volcano and surrounding areas of Yogyakarta City, Indonesia; (2) the large-scale afforestation of agricultural areas to reduce soil erosion in Guyuan, China; (3) the expansion of soil and water conservation measures in the Oum Zessar watershed, Tunisia; (4) the agricultural intensification and the potential for organic agriculture in Bijapur, India; and (5) the land degradation and land conflicts resulting from land division and privatisation in Narok, Kenya. All five regions are characterised by population growth, partially combined with considerable economic development, environmental degradation problems and social conflicts. Implications of the regional scenario impacts as well as methodological aspects are discussed. Overall, FoPIA proved to be a useful tool for diagnosing regional human-environment interactions and for supporting the communication and social learning process among different stakeholder groups.

5.1   Introduction

Population growth and economic development are important drivers that change the demand for land-based products and services on a global scale and often lead to land intensification and land use conflicts (e.g., Lambin et al. 2003; Metzger et al. 2006). The need for sustainable development (SD) is omnipresent, but SD is difficult to be made operational. Therefore, policymakers are increasingly demanding comprehensive and reliable analyses of policy impacts on the economic, social and environmental dimensions of SD (Helming et al. 2011a).

Choosing a particular approach for impact assessment depends on various factors, such as the specific decision context, regional aspects, available resources, and the preferences of stakeholders (Uthes et al. 2010). In land use studies and impact assessments, stakeholder

participation is recognised to be crucial, for example, when addressing multifunctional land use (Binder et al. 2010; De Groot 2006; O'Farrell and Anderson 2010), in the development of sustainability indicators (Fraser et al. 2006; Reed et al. 2005; Reed et al. 2006), to specify a context-specific problem (Schwilch et al. 2012; Walter and Stützel 2009), to define causal relationships between human activities and their impacts (Carr et al. 2007; Tscherning et al. 2012), and to develop regionally sound scenarios (Kok et al. 2006; Tress and Tress 2003).

With regard to sustainability impact assessment in developing countries, with their limited data availability and quality, need for integration, handling of complexity, and lack of literature, the Framework for Participatory Impact Assessment (FoPIA) (Morris et al. 2011) is a potentially useful and straightforward approach. FoPIA was originally developed for application in the European Union to conduct stakeholder-based impact assessments of alternative land use policies, for example, to assess the policy options for biodiversity conservation in Malta (Morris et al. 2011). This approach has been adapted for the assessment of land use policies in developing countries (König et al. 2010).

The present paper examines the utility of the FoPIA approach in the context of different regions in developing countries by presenting and discussing the main findings from a series of FoPIA impact assessment studies in five independent regions. The five regions are all experiencing fundamental land use changes resulting from strong drivers such as population growth, economic development and climatic changes. Each region, however, has a specific focus (Table 5.1), such as on alternative spatial planning policies in Yogyakarta (Indonesia) (see König et al. 2010), different implementation levels of large-scale afforestation to prevent soil erosion in Guyuan (China) (see König et al. in press), agricultural intensification and the potential for organic agriculture in Bijapur (India) (see Purushothaman et al. in press), different implementation levels of soil and water conservation measures in the Oum Zessar watershed (Tunisia) (see König et al. 2012), and land privatisation and land use conflicts in Narok (Kenya).

Table 5.1. Case study characteristics and attributes of regional land use problems and policy options.

Case study	Main land use problem	Policy options
Yogyakarta (Indonesia)	Expansion of settlements causing deforestation and conversion of paddy fields	Forest protection and paddy field conservation
Guyuan (China)	Agricultural activities on steep slopes causing soil erosion, sand storms and land degradation	Conversion of farmland into forests and grassland
Oum Zessar (Tunisia)	Limited water resource availability causing low agricultural productivity	Promotion of soil and water conservation measures
Bijapur (India)	Marginalization of small-scale farmers causing credit debts and farmers' suicides	Promotion of low input farming practices (organic farming)
Narok (Kenya)	Land use conflicts between livestock- and crop farmers and wildlife conservation	Promotion of either crop production, livestock production or ecotourism

5.2 The Framework for Participatory Impact Assessment (FoPIA)

5.2.1 General approach

FoPIA provides a general assessment framework, a template that can be adjusted to different regional contexts of developing countries (see König et al. 2010). It comprises a preparation phase and a regional stakeholder workshop, that follows a structured sequence of assessment steps as illustrated in Table 5.2, namely (i) interactive development of regional land use scenarios, (ii) specification of the regional sustainability context, (iii) and assessment of scenario impacts and analysis of possible trade-offs. The workshop is followed by an evaluation phase in which the workshop results are further analysed and documented (Table 5.2).

The scenario development (step i in Table 5.2) starts with a characterization of the main case study attributes. Scenario assumptions are defined together with regional stakeholders, firstly to consider relevant and implicit regional information and secondly, to achieve a common basis of understanding. The specification of the regional sustainability context (step ii in Table 5.2) has the objective of putting the concept of SD into the regional context by using land use functions (LUFs) (Pérez-Soba et al. 2008). LUFs structure the assessment problem and allow for an equal consideration of the economic, social and environmental dimensions of sustainability. Stakeholders assign

weights of perceived importance to the different LUFs, using a scoring scheme from 0 to 10 (0 = least important; 10 = most important). Weighing results are used to present different perceptions of LUF priorities as to derive a 'picture' of regionally more or less important LUFs. The same weight can be assigned to more than one function. After the assignment of individual weights, average weights are calculated and presented back to the group for discussion. A second scoring round is used to allow for an adjustment of weighing scores. For the impact assessment (step iii in Table 5.2), each LUF is assigned one corresponding indicator in order to have a precise measurement for the scenario impact assessment (see Table 5.5). Stakeholders are asked to propose regionally relevant indicators to elaborate an operational set of indicators. For the indicator selection, the following criteria are applied: the indicator should be relevant to the corresponding LUF, the indicator should be understandable to all participants, and the indicator should not be redundant to other indicators.

A scoring scale from - 3 to + 3 is used to assess negative or positive impacts, respectively, with the following scores: 0 = no impact; - 1 and + 1 moderate impact; - 2 and + 2 high impact; and - 3 and + 3 extremely high impact (cf. Morris et al. 2011). After completion of the individual scorings, average impact scores for each scenario on each LUF indicator are calculated and presented back to the group. In order to initiate a discussion, the workshop moderator presents the group average score and highlights contrasting positive and negative impact scores. This step is important to make the participants reveal their arguments for the different scorings. After group discussion, one to two rescoring rounds are conducted to allow participants to readjust their scores as needed.

The overall assessment of the scenarios for the three sustainability dimensions is based on an aggregation of the scenario impact scores and LUF weights as expressed by following equation:

$$wi_d = \sum_{f=1}^{n} w_{f,d} * i_{f,d} \qquad (1)$$

With: w_i = weighted impact, w = weight assigned to each land use function, i = average impact for each land use function, d = sustainability dimension (economic, social, environmental), f = land use function (n = 9).

This allows for comparison of different scenarios and a ranking of scenarios, based on which, possible implications for land use and decision support can be discussed.

Table 5.2. Sequence of FoPIA.

Assessment steps		Activities	Who*	Time[+]
Preparation phase		Gathering and analysis of available literature and material to allow for a first understanding of the regional land use problem supported by informal meetings with experts, stakeholder selection and invitation, preparation of workshop materials	R	Several weeks
Stakeholder workshop (1-2 days)	Opening	General introduction and explanation of the goals and sequence of FoPIA	M	2-3 hours
		Self-introduction of the stakeholders (icebreaker)	S	
	Scenario development (step i)	Presentation of the status quo of the regional land use situation	M	
		Moderated discussion, case study and problem definition	S (M)	
		Definition of land use drivers and policy selection, elaboration of scenario assumptions	S (M)	
	Specification of the sustainability context (step ii)	Presentation of land use functions (LUFs)	M	2-3 hours
		Regional definition of LUFs	S (M)	
		Paper-based weighing of importance of LUF (2 rounds), presentation of result after each round (diagrams, tables), moderated discussion	S (M)	
	Scenario impact assessment (step iii)	Elaboration and selection of LUF assessment indicators	S (M)	3-4 hours
		Paper-based assessment of scenario impacts on each LUF by the stakeholders (2-3 rounds), presentation of group result (diagrams, tables) after each round, discussion of impact result	S (M)	
		Presentation of weighted scenario results, discussion of policy implications and consequences for regional sustainable development	M, S	
		Evaluation of the workshop	S	
Evaluation phase		Processing of results, identification of policy recommendations and report writing	R	Several weeks

*R – Researchers, M – Moderator(s), S – Stakeholders, [+] broad orientation

5.2.2 Regional adaptation

The preparation phase for the five regions included the gathering of relevant background information on land use developments, related conflicts and policy options to allow for a first drafting of scenarios, which were further specified during the stakeholder workshops, the translation of the workshop material into the regionally spoken languages, the formation of the moderation team as well as the stakeholder selection and invitation (Table 5.2). A one to two days' assessment workshop with ten to fourteen stakeholders was held in each case study (Table 5.3).

Table 5.3. FoPIA workshop settings.

FoPIA Workshop	Language	n total	administration	scientists	NGO personnel	farmers
Yogyakarta (May 2009)	Bahasa	14	8	4	2	0
Guyuan (August 2009)	Lan-Yin	10	8	2	0	0
Oum Zessar November 2009)	French	10	10	0	0	0
Bijapur (June 2010)	Kannada	11	0	3	1	7
Narok March 2011)	English	12	6	4	1	1

The workshops were organized as part of longer study visits, including field trips and meetings with farmers, experts, NGO personnel as well as decision makers responsible for the implementation of land policies, in order to get familiar with the regional land use problems, land management practices and policy options.

The FoPIA research team in each region consisted of five (Narok) to seven (Bijapur) researchers, with two to five regional researchers and two or three from European countries. The regional adaptation of the FoPIA method was based on a regional context analysis and considered the research interests of the regional research partners.

General criteria for the selection of workshop participants in all regions included that participants needed to be familiar with the regional context and policy options, representing relevant land use sectors, and should cover the different sustainability dimensions. These criteria served as an orientation, but often had to be comprised, for example, when the targeted stakeholders are not able to join the workshops for reasons of

time or motivation. Specific selection criteria in each region were defined upon the regional assessment problem and responding policy option, and in close cooperation with the regional research partners. Participants included usually groups or individuals, either being responsible for the formulation or implementation of the policy (e.g., land administration and local governments, scientists, NGOs) or being affected by policy implications on land management (land users) (for an overview of the workshop participants, see Table 5.3). In Narok, for example, the identification of potential FoPIA participants started by surveying the available literature (journal articles, reports) for regional experts dealing with the problems of land division and land degradation in this area, which were contacted via E-mail (affiliated to ILRI[6], ICRAF[7], FAO[8], UON[9], KARI[10]). The regional research partners in Nairobi invited a semi-pastoralist Maasai from the region, to whom they had been in contact with from previous studies, as well as the district officers for agriculture and livestock production.

In each region, a workshop moderator was responsible to guide the stakeholders through the different FoPIA steps, to initiate discussions, to synthesize main findings and to bridge possible communication gaps between different disciplines. In most cases, a team of two moderators was involved, one responsible for the methodological guidance, the other one responsible for translation into the local language.

Draft scenarios were developed by the FoPIA research teams during the preparation phase, based on available literature and information from the regional partners. These draft scenarios were presented at the workshops and further developed and quantified with the stakeholders. In Yogyakarta, for example, the three scenarios (no-policy, forest protection, paddy field conservation) were proposed by the regional partners, as these policy options and respective instruments (laws) are publicly discussed or already approved but not enforced. These options were presented to the stakeholder group, and the stakeholders discussed about their implications on the different land use sectors in the area. The scenarios were translated into concrete land use changes for the scenario target years, and the impacts of these changes on the LUFs were assessed.

The final scenarios developed for the five regions are shown in Table 5.4. Land use considered regionally relevant sectors including agriculture, forestry, nature conservation

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6 ILRI International Livestock Research Institute
7 ICRAF International Center for Research in Agroforestry
8 Food and Agriculture Organization
9 University of Nairobi
10 Kenya Agriculture Research Institute

and built-up areas. All scenarios were assumed to be exposed to population growth (1-3%), economic development (3 to 12%) and climate variability assuming that these drivers lead to increasing consumption of natural resources and changes in land use patterns. The scenario target year was independently defined at contextual relevance of policy- and sustainable development targets for each region. Scenario narratives included two alternative policy scenarios and one reference scenario (REF) to allow for comparison of policy impacts (Table 5.4).

The original set of LUFs as proposed by Pérez-Soba et al. (2008) for the European Union were used as a starting point and adapted to the different regional contexts as needed, resulting in a final set of LUFs as shown in Table 5.5. For all regions, the LUF 'human health' was replaced by the LUF 'quality of life' (SOC2) in order to consider regional factors affecting rural life in general, including human health issues but also income available that could improve the living standards of rural people above subsistence needs (Table 5.5). The LUF 'cultural identity' was replaced by the LUF 'food security' (SOC3) that was considered to be a major concern of local people in all regions except in the case of Oum Zessar. The SWC measures in Oum Zessar aim to improve agricultural productivity (e.g., with the goal of allowing the growing of olives); food security, however, was not considered to be a critical issue in this region due to less rural poverty compared to the other regions (see König et al. 2012).

As for the impact assessment, the indicator selection process was independently done for each case study and resulted in a varied list of quantitative and qualitative indicators (Table 5.5). The LUF weighing and impact assessment was done by each participant separately, using prepared assessment sheets. This procedure avoids that individual participants are influenced by other group members. The sheets were collected after each round, results typed into a spread sheet and displayed to the group on a projector. The group average per LUF and the range of the values were presented back to the group. The moderator led the discussion by asking the participants after their arguments for the different assessments, and pointed particularly at contrasting assessment results. All assessment arguments were documented by the research team, and clarified if needed. The main results were distributed among the stakeholders at the end of each workshop.

Table 5.4. Regional scenario description.

Area and target year	Drivers	Reference scenario (REF)	Policy scenario 1 (S1)	Policy scenario 2 (S2)
Yogyakarta 2025	P: +1% E: +7%	Urban: Uncontrolled conversion of mainly paddy fields into settlements, some deforestation	Forest: Maintenance of forest in the mountain terrain. Land conversion of paddy fields into settlements	Paddy: Conservation of paddy fields in the surroundings of the city. Limited land conversion, some deforestation
Guyuan 2020	P: +2% E: +12%	No policy. Small-scale agriculture on steep slopes	SLCP-p1: Conversion of cropland into forest on steep slopes (above 25°)	SLCP-p2: Additional afforestation on slopes between 15-25°
Oum Zessar 2015	P: +2% E: +3%	SWC-70: Implementation of soil and water conservation (SWC) measures at 70% coverage of manageable land	SWC-85: Implementation of SWC measures at 85% coverage of the manageable land	SWC-100: Implementation of SWC measures at 100% coverage of manageable land
Bijapur 2015	P: +2% E: +11%	Transition: Beginning shift from traditional agriculture towards market oriented and commercial agriculture	Organic: Limited use of external inputs, biological pest control, use of organic manure. Extension service provided by local NGOs	Non-organic: Expansion of cash crop production, subsidies for industrial inputs, contracts with companies
Narok 2030	P: +3% E: +3%	Crop: Expansion of market oriented crop production, reduction of common land (overgrazing), decrease in wildlife area	Livestock: Promotion of intensive livestock production, increase in fodder area, decrease in wildlife area	Ecotourism. Expansion of areas for wildlife conservation, limited expansion of livestock and crop production

Note: P = annual population growth at the national level, E = annual economic development at the national level (estimates based on national statistics)

Table 5.5. Land Use Functions and corresponding assessment indicators.

Land use function (LUF)		LUF definition	LUF indicator	Y	G	O	B	N
ECO1	Land based production	Provision of land for economic production including agricultural and forest products	economic production	x	x		x	
			on-farm income			x		x
ECO2	Non-land based activities	Provision of space used for industry and service activities	built-up activities	x	x			
			off-farm income					x
			regional investments			x		
			access to financial services				x	
ECO3	Infrastructure	Quantity/quality of roads as means to connect rural regions with outer regions	road density and quality	x	x	x		x
			access to markets				x	
SOC1	Provision of work	Employment opportunities for activities based on natural resources	regional employment	x	x	x		x
			working conditions				x	
SOC2	Quality of life	A 'good' living standard in rural regions related to factors that should improve the quality of life	human health				x	x
			life expectancy	x		x		
			income		x			
SOC3	Food security	Availability of sufficient quantity and quality of food	food availability	x	x			x
			food from farm				x	
	Cultural identity	Values associated with local culture	traditional land use			x		
ENV1	Provision of abiotic resources	The role of land in regulating the supply and quality of soil and water	water availability	x		x	x	x
			soil structure and erodibility		x			
ENV2	Provision of biotic resources	Provision of habitat and factors affecting the capacity of the land to support regional biodiversity	habitat and biodiversity		x		x	x
			vegetation cover			x		
			conservation area	x				
ENV3	Maintenance of ecosystem processes	The role of land in the regulation of natural processes and ecological supporting functions	undisturbed land		x	x		
			soil health				x	x
			clean water	x				

Note: *Y =Yogyakarta, G=Guyuan, O=Oum Zessar, B = Bijapur, N = Narok.

5.3 Results

5.3.1 Regional preferences for land use functions

The regional preferences for the different LUFs (average weights) are shown in Table 5.6 ('w'-columns). The weights reflect the specific needs of the five regions. Land based production (ECO1), for example, was of highest importance in all predominantly rural regions (Guyuan, Oum Zessar, Bijapur, Narok), but of lowest importance in the rural-urban region of Yogyakarta, where more emphasis was put on non-land based production (ECO2) and infrastructure (ECO3, Table 5.6). In the case of Narok, infrastructure (ECO3) was considered an important factor that links remote rural regions with the capital city for economic exchange. In the poorer regions of Yogyakarta, Bijapur and Narok, food security (SOC3) was a major concern and therefore among the highest rated functions (Table 5.6). The stakeholders in Bijapur reflected on the largely subsistence character in their region and the need to improve living conditions for rural people (quality of life, SOC2). In the case of Yogyakarta, increasing demand of food supply is needed to meet the needs of a growing urban population. Environmental LUFs were given relatively high weights in all five regions, reflecting the critical situation of growing demands for natural resources often leading to threatening important environmental functions. However, environmental LUFs were not of absolute highest priority, except for the case of Narok where the LUF biotic resources (ENV2), referring particularly to wildlife protection, was given the highest weight, together with land-based production (ECO1) and food security (SOC3).

Overall, preferences in Yogyakarta showed not much variation, as the stakeholders assigned relatively high weights to all LUFs. In contrast, the stakeholders in Oum Zessar differentiated clearly between the nine different LUFs. Although the weights give a subjective picture and are influenced by the composition of the stakeholder group, the level of variation may also be interpreted as a hint for the severity of the conflicts in the five regions.

5.3.2 Impact assessment results

Yogyakarta, Indonesia

In Yogyakarta, spatial planners are confronted with the challenge to stop uncontrolled urban settlement resulting from population growth, while maintaining existing forests and

agricultural areas used for paddy field production. The regional forests act as buffer zones to reduce the risk of landslides during volcano eruptions and ensure the provision of abiotic and biotic resources to the region, while the paddy fields are important in terms of regional and affordable food production. In the REF-scenario (Table 5.4), the uncontrolled spreading of settlements leads to a reduction of the forest and paddy field area with negative impacts on land-based production (ECO1), quality of life (SOC2), food security (SOC3) and all environmental LUFs. Considering the regional preferences for the different LUFs (Table 5.6), the forest scenario (S1), which assumes the implementation of a forest protection law and control of the settlements (Table 5.4), is the most favourable scenario with regard to sustainable development. Some increase in settlement, however, is unavoidable in this scenario in the opinion of the stakeholders, which further reduces the paddy-field area, thus also reducing land-based (agricultural) production (ECO1) and the provision of work (SOC1, Table 5.6). The agricultural area reduction is not that dramatic so that the regional food security would be at risk, and, as the stakeholders argued, a greater reliance on non-regional food production as results from the decrease in paddy fields, although perhaps not desirable, is at least possible, whereas the protective and regulatory function of the forests can only be realized on site. The paddy field scenario (S2), in contrast, assumes that paddy fields are largely maintained (Table 5.4) leading to positive impacts for most LUFs (Table 5.6), while urban sprawl is controlled like in the forest scenario but here the unavoidable increase is to the disadvantage of the forest area reflected in negative impacts on abiotic resources (ENV2) and ecosystem processes (ENV3). A critical point in the two policy scenarios (S1, S2; Table 5.4) is that they assume that uncontrolled settlements can be stopped, which inevitably implies a change of traditional housing and an increase of the population density per square meter to meet the demands of the growing population while reducing the consumption of land by settlements. Careful planning and improved enforcement and delivery mechanisms are required to achieve this, which is easily said, but in fact the greatest hindering factor for putting the spatial policy scenarios into practice in Yogyakarta (cf. Partoyo and Shrestha 2011).

Guyuan, China

In Guyuan, regional problems of soil erosion and degradation were caused by the small-scale agricultural use of fragile loess soils on hillsides (Zhen et al. 2009a) and exacerbated by population growth through in-migration and increasing land use. The land

degradation is also of super-regional relevance as it contributed to the formation of devastating sandstorms reaching far-away urban areas (Table 5.1). In response, a large scale afforestation program (sloping land conversion program, SLCP) was implemented, which included conversion of agricultural land into grassland and forests and compensation in terms of grains, seedlings and financial aids to affected farmers. Afforested areas are either designated as "ecological forests", with only little economic orientation, or "economic forests" including for example fruit shrubs with the clear intention of offering marketable income. FoPIA was used to assess the situation in Guyuan without the SLCP (REF-scenario) and two policy scenarios differing in the area afforested (SLCP-p1: actually afforested area in the period 2000 to 2008; SLCP-p2: hypothetical further expansion of the SLCP to sloped areas of 15° and more, Table 5.4). The impacts of afforestation (both scenarios) were assessed to be positive, particularly with regard to improvement of environmental LUFs (Table 5.6), and a further expansion of the program (SLCP-p2) was advocated subject to the availability of public funds. However, the FoPIA workshop also revealed that the region has only little potential in non-agricultural sectors. The provision of agricultural labour (SOC1) is continuously declining, leading to off-farm migration of the working population, while mainly children and the elderly remain in the villages. This point was also addressed by Cao et al. (2009b). These trends would be worsened by the expansion of the SLCP in the opinion of the stakeholders. In the past, vocational trainings were organized to train farmers how to take care of the tree seedlings and maintain afforested areas. Compared to on-farm activities, the forestry sector provides only limited job opportunities to local people in Guyuan because large parts of the afforested areas are mainly established to mitigate soil erosion and not for economic production. In the long run, the emerging service and industrial sector on the national scale could offer potential to absorb agricultural labour, but this would require specifically targeted trainings to avoid farmers to become part of the unskilled labour sector.

Oum Zessar, Tunisia

The Tunisian case study region is dry watershed (Table 5.1), in the upstream of which agricultural productions systems using water harvesting techniques and irrigation are located, while rain-fed agro-pastoral systems are mainly found in the downstream (Ouessar et al. 2004). Water harvesting techniques have traditionally been used to allow for agricultural land use in this very dry area, but were not adequately maintained over the

years. Re-installing the traditional systems as well as the development of new water harvesting measures was the objective of the soil and water conservation (SWC) program, to optimize the water use efficiency and increase agricultural productivity (cf. Ouessar et al. 2004). The further expansion of SWC measures towards the initial policy goal of covering 85% of the manageable land (SWC-85, S1; Table 5.4) as well as a possible additional implementation (SWC-100, S2; Table 5.4) were both assessed as particularly positive for land-based production (ECO1), and related to this, provision of work (SOC1) (see Table 5.6). Biotic resources (ENV1), in terms of vegetation cover and crop diversification, would also benefit, while the introduction of modern water harvesting measures would lead to reduced cultural identity (SOC3). In general, the SWC measures benefit primarily all production systems in the upstream, where the water is harvested and consumed while the grazing area in the downstream is negatively affected in terms of fodder quality and quantity due to a disturbance of ecosystem processes (ENV3). A further expansion of the SWC measures would increase the mentioned positive effects but also further disturb ecosystem processes and thus further marginalize the mixed agro-pastoral systems in the downstream (SOC3). In the opinion of the stakeholders the positive impacts outweigh negative impacts, therefore a further extension of the SWC measures to 100% of the possible area was the most favourable scenario. An overall assessment of the economic benefits from this expansion, however, requires consideration of both on-site and off-site effects of the SWC measures (Fleskens et al. 2005), which was not part of our study.

Bijapur, India

Government incentives and the provision of micro-credits aimed to increase agricultural productivity in India to meet the growing demands for food of the rapidly growing population and has induced a transformation from traditional-subsistence to market-oriented intensive agriculture (cf. Fan et al. 2008). Growing cash crops, such as oilseeds and cotton, however, causes ecological problems resulting from agricultural intensification and bears a high risk of revenue losses in drought years, particularly for small-scale farmers (< 2ha). These changes contributed to farmers' distress with devastating consequences such as farmers' suicides (cf. Purushothaman and Kashyap 2010; Shrishail et al. 2011). In the opinion of the regional small scale farmers, the REF-scenario for Bijapur, representing the transition situation (Table 5.4), which has not progressed that far, has only little impact on all LUFs (Table 5.6). A strong promotion of

non-organic commercialized agriculture as represented by the S2 scenario, however, is seen as the most unfavourable scenario for sustainable development, as the aforementioned trends will be strongly worsened, leading to negative impacts for all LUFs, (Table 5.6). The promotion of organic farming (S1) is the most favourable scenario (positive for all LUFs, Table 5.6), as organic farming creates self-sufficient agriculture with only little dependence on external inputs and is close to the cultural and traditional ideals of the farmers of a sustainable use of nature. With regard to land-based production (ECO1), it would have been expected that in principle, organic farming has lower yields compared to conventional production. In the case of Bijapur, however, where extreme weather events frequently occur (droughts), non-organic agriculture is susceptible to high yield losses (high risk), therefore organic farming is positively assessed (over the years), from the perspective of the small-scale farmers. However, the scaling-up potential of organic farming is unclear since policy support and certification standards, which could allow for a better marketing of organic products, and thus allow for a viable enterprise, are lacking. Until now there are only a few pilot villages, in which organic farming is tested with support from the government and local NGOs.

Narok, Kenya

In Narok district, land division and privatization[11] combined with steady population growth, represented by the REF-scenario, lead to competition for land and overexploitation of natural resources resulting in deterioration of important environmental functions (ENV 1-3, Table 5.6). Former rangeland areas are converted for crop production, reducing drastically the area for wildlife (negative impact on biotic resources, ENV2, Table 5.6). The crop area is often farmed intensively and managed by co-existent large-scale agriculture and small-scale farmers. Land conversion and an increase in land renting also reduce the area for the Maasai, who are mainly located in the less fertile area and operate a mixture of pastoralism and nowadays crop production. This leads to higher livestock densities and associated negative environmental impacts (Seno and Shaw 2002). Although the stakeholders mentioned that the REF-scenario leads to a decline of the traditional Maasai lifestyle and unequal distribution of wealth, the overall impacts on economic and social LUFs were assessed to be positive (Table 5.6), since the scenario ultimately increases land-based production (ECO1) and improves food security (SOC3),

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[11] A detailed description of the land division process can be found in Seno and Shaw (2002) and Mwangi (2007).

both highly-weighted LUFs (Table 5.6). The Livestock-scenario (S1) promotes intensive livestock production to meet Kenya's growing demand for beef and to generate higher added value compared to crop production. Overall and taking into account the perceived importance of the different LUFs, this scenario was rated better than the REF-scenario, although the direction of the impacts was similar. Rangeland is converted for crop and fodder production. Fodder areas are seen as less negative for wild animals than crop areas, thus the negative impact on biotic resources is lower than in the REF-scenario. The ecotourism scenario (S2) assumes that areas with high density and varieties of wildlife are designated as ecotourism areas, which are managed by the local communities, allowing the Maasai to maintain their lifestyle better than in the other two scenarios, while also improving their economic situation. The scenario leads to less land conversion for crop and fodder production, which promises the maintenance of important environmental functions (ENV 1-3) while increasing non-land-based production (ECO2). However, land-based production (ECO1), provision of work (SOC1) and food security (SOC3) are less positively influenced than in the other two scenarios. Overall, the ecotourism was rated best for sustainable development (Table 5.6), but it has, as some stakeholders argued, the lowest probability of being realized due to lack of appropriate policy instruments and implementation mechanisms.

Table 5.6. Impact assessment of alternative land use scenarios on economic, social and environmental Land Use Functions.

Region	Scenario	ECO1 w	ECO1 i	ECO2 w	ECO2 i	ECO3 w	ECO3 i	SOC1 w	SOC1 i	SOC2 w	SOC2 l	SOC3 w*	SOC3 i	ENV1 w	ENV1 i	ENV2 w	ENV2 i	ENV3 w	ENV3 i	w_{ECO}	w_{SOC}	w_{ENV}	wi
Yogyakarta	REF (Urban)		-2.00		1.85		1.54		1.69		-1.15		-2.08		-2.15		-2.08		-2.23	13.0	-13.9	-51.3	-52.2
	S1 (Forest)	7.6	-0.08	8.5	0.38	8.1	0.38	7.9	-0.08	7.8	1.77	8.8	0.38	8.0	2.00	7.7	2.15	8.1	1.85	5.8	16.6	47.5	69.9
	S2 (Paddy)		1.69		0.08		0.54		0.85		1.77		2.54		-0.08		0.08		-0.62	17.9	42.8	-5.0	55.7
Guyuan	REF (no policy)		0.44		0.67		1.00		-0.44		-1.00		0.11		-1.89		-0.78		-1.00	13.9	-8.9	-25.7	-20.7
	S1 (SLCP-P1)	8.5	1.44	6.0	1.00	6.1	1.00	6.1	-0.44	7.0	1.67	7.1	1.44	6.5	1.78	7.6	1.44	7.5	1.67	24.4	19.2	35.0	78.6
	S2 (SLCP-P2)		1.67		1.44		1.56		-1.11		2.22		2.11		2.78		2.44		2.78	32.3	23.8	57.5	113.6
Oum Zessar*	REF (SWC-70)		1.30		0.40		0.00		0.30		0.40		1.50		0.70		0.40		-0.10	12.4	14.5	7.3	34.2
	S1 (SWC-85)	8.0	1.60	5.1	0.60	4.4	0.50	7.9	1.50	7.4	0.70	6.0	0.80	7.7	0.40	6.3	1.70	6.3	-0.50	18.1	21.8	10.6	50.5
	S2 (SWC-100)		2.00		0.30		1.40		1.90		0.90		0.50		0.10		2.40		-1.40	23.7	24.7	7.1	55.5
Bijapur	REF (Transition)		0.40		0.10		-0.10		0.20		-0.10		0.00		0.00		0.10		-0.20	3.2	0.5	-0.9	2.8
	S1 (Organic)	8.3	1.30	6.3	1.10	7.1	1.10	7.1	1.50	9.5	0.90	9.3	1.20	8.4	1.70	7.1	1.60	8.8	1.70	25.5	30.3	40.4	96.2
	S2 (Non-organic)		-1.10		-0.80		-0.50		-1.30		-1.50		-1.20		-1.50		-1.40		-1.40	-17.7	-34.5	-34.7	-86.9
Narok	REF (Crop)		2.46		0.15		2.15		2.23		1.00		2.62		-0.69		-2.31		-0.69	33.5	43.6	-28.3	48.8
	S1 (Livestock)	8.0	2.23	5.8	0.46	6.0	1.85	6.8	1.85	7.6	1.77	8.0	2.31	6.9	-0.46	8.0	-1.46	7.3	0.08	31.6	44.3	-14.3	61.6
	S2 (Ecotourism)		0.54		1.54		1.69		0.92		1.15		0.54		1.62		1.92		1.00	23.4	19.3	33.9	76.6

Note: w = average weights for the different LUFs reflecting the regional preferences; i = average impact of the scenarios; wi = weighted impact.

*For the case of Oum Zessar watershed, the LUF *Food security* (SOC3) was replaced by *Cultural identity.*

94

5.4 Discussion

5.4.1 Evaluation of the workshops

Table 5.7 compares the five FoPIA workshops along a list of qualitative criteria. The first FoPIA workshop was conducted in Yogyakarta in Indonesia. Preparation efforts were rather high as it was difficult to get access to regional background information, and all workshop materials had to be translated into local language. The workshop itself started with the self-introduction of the stakeholders, followed by the explanation of the method and relevant concepts (sustainability, land use functions), which was too complex and tiresome for some participants, as the workshop evaluation at the end revealed. The introductory part was therefore reduced to a minimum for the following workshops in the other regions. Moreover, the relatively big group size (n=14) combined with a hierarchical structure in which older and more educated participants took the floor had an intimidating effect on other participants. For the impact assessment, the group was therefore temporarily divided into two smaller groups with a separate moderator each that assured that the arguments from all participants were heard. For the final discussion at the end of the workshop, the two groups came together again. For the following workshops, the conclusion was drawn that the group size should not exceed ten to twelve participants to avoid this problem. The atmosphere in Yogyakarta during the workshop was concentrated and results comprehensible. Participants were positive about the FoPIA method, and suggested for future applications, a GIS-based visualization of the different scenarios, for example, by using spatially explicit scenario tools (e.g., Fürst et al. 2010) and with explicit consideration of environmental risks maps (e.g., Hadmoko et al. 2010).

The FoPIA in Guyuan was done during a longer research stay in the region, and accompanied by household surveys and a participatory rural appraisal. The preparation involved (apart from collecting all necessary background information) several meetings with the responsible decision makers. The workshop participants consisted mainly of administration staff from different departments responsible for the planning and implementation of land use policies in Guyuan, as well as two scientists (Table 5.3). The selected group was very confident and motivated, which led to a lively discussion. Overall, the actors in the Chinese case study were satisfied with the method and the sequence of the workshop and were open for further cooperation. Since the method is relatively fast and transparent and results are shown in easy-to-understand diagrams, this

was seen as particularly positive, as well as the fact that FoPIA creates an "event" to meet the other parties. The possible adverse effects of the afforestation program on the provision of work (SOC1) clarified that in future applications of FoPIA a further differentiation of the types of trees used for afforestation is needed and thus whether the orientation of the SLCP is more ecological or economic. One participant preferred a more differentiated impact assessment scale with decimal points, but this point was not shared among the group. The use of more than one indicator per LUF was suggested but then rejected as this would have brought along the need for calculating composite indicators, reducing the appreciated transparency of the method. With regard to the results, the group was relatively optimistic and agreed about the impacts of the SLCP (both scenarios). Due to lack of or non-access to monitoring data, the percentage of successfully afforested area and possible economic benefits for the farmers cannot be determined. Studies on similar programs in China found that compensation payments for farmers may not fully compensate the opportunity cost of the land conversion (Fen et al. 2007; Uchida et al. 2005), and may thus contribute to rural poverty and off-farm migration.

The Tunisian workshop was held under tight time constraints due to the delayed arrival of some stakeholders. The participants were then very motivated to bring in their knowledge, particularly with regard to scenario and indicator development, but were also very keen on discussions. Eventually, this caused some time pressure for impact assessment, final discussion and workshop evaluation. Therefore, an evaluation of this workshop is only partially possible. The lesson learnt from the workshop is that it requires greater rigorousness from the moderator in future applications. During the short discussion at the end, stakeholders evaluated the workshop positively, but proposed, like in Guyuan, to use more than one indicator per LUF, but the implications of this suggestion could not be fully elaborated.

In Bijapur, FoPIA was adapted to the research field of the regional research partners and thus applied to a group of predominantly small-scale farmers with the aim of testing the applicability of the method among stakeholders with only basic education. The workshop started two and half hours delayed due to a bus breakdown on the way to the workshop venue, which required shortening all workshop steps. However, in comparison to the other regions, the discussion was not very controversial. Arguments such that certification standards for organic farming are not yet established were not disclosed. Thus, the workshop would have benefited from a participation of additional experts or stakeholders

from the policy implementation level to assess the potential of organic farming for Bijapur from a more scientific point of view. The scenario results reflect, therefore, only how the situation might develop for the small-farmers under the different scenarios and not how the whole region would develop. The workshop evaluation by the participants was very positive, but it remained unclear whether this was the true opinion of the stakeholders or whether the whole workshop set up (bus trip, hotel venue, technical equipment, presence of foreigners) had an intimidating effect on them.

The workshop atmosphere in Narok was friendly and well-balanced. Only in this group, stakeholders explored the effect of 'playing' with different LUF weights on the overall assessment of the scenarios. Although the scenarios were complex and assessed to have heterogeneous effects on the different LUFs, depending on the perspective taken (arable farms, Maasai, rest of society), the participants managed to weigh the differed developments and come to an overall assessment. The method was positively evaluated, particularly with regard to its consideration of all three sustainability dimensions in one approach and because of its stakeholder-focused approach.

Table 5.7. Qualitative assessment of FoPIA workshops based on own reflections.

Region	Discussion culture	Assessment opinions	Plausibility of results
Yogyakarta	hierarchical	heterogeneous	comprehensible
Guyuan	cooperative	heterogeneous	possibly biased
Oum Zessar	tense	heterogeneous	comprehensible
Bijapur	cooperative	homogenous	possibly biased
Narok	cooperative	heterogeneous	comprehensible

5.4.2 Overall assessment of FoPIA

The five applications show that FoPIA is a useful tool for assessing land use scenarios in developing countries. This tool facilitates the communication and social learning process among stakeholders, who must sit together for the assessment and are encouraged to exchange their different viewpoints and arguments at several points during the workshops. Moreover, the method provides guidelines throughout the assessment process with a focus on considering sustainability as a holistic picture. The method is also relatively simple and is therefore generally suitable for different stakeholder groups;

however, a certain education level amongst the stakeholders is advantageous for the understanding of the different components (scenarios, indicators, LUFs).

The inclusion of various stakeholder groups implies that FoPIA must strike a balance between simplification and complexity. A crucial aspect in the impact assessment step refers to the selection of regionally relevant and operational indicators. In most cases, economic and environmental indicators were well understood by the stakeholders, whereas some participants indicated that the assessment of the social indicator 'quality of life' (SOC2) remained unclear in terms of quantification and was also difficult to differentiate from economic indicators (cf. Wiggering et al. 2006). Moreover, several researchers in the five regions criticised the one-indicator-per-land-use function solution. Other stakeholders, for example, farmers, found the one-indicator-per-land-use-function solution already relatively complex and opposed using additional indicators. The consideration of several indicators per land use function would have required the creation of composite indicators, with additional weights for the individual indicators, and would have added more complexity and less transparency to the workshops; therefore, this option was omitted (cf. discussion of this aspect in Reidsma et al. 2011).

The results of the assessment are determined by the involved stakeholder group. The number of invitations in all of the regions was higher than the actual targeted group size, as it was often difficult to get all of the targeted persons to attend the same workshop, leading to some uncertainty of the final group size and composition. The workshops had to be planned relatively early, although the stakeholders confirmed their participation relatively late when adjusting the workshop dates was no longer possible. In future applications, more flexibility regarding the workshop date might allow for better balanced group compositions (particularly in remote regions such as Guyuan and Bijapur), preferably with contrasting interest groups that include representatives from socially oriented interest groups (e.g., NGOs, extension service and education centres, different tribes, religious groups or women's groups), economic groups (economically oriented land users, land use planners, representatives from the industry, energy and service sector), and environmental groups (conservationists, environmental agencies, NGOs).

Although the aim of this study was not to analyse the possibility of actually implementing a scenario, stakeholders were often interested in addressing the institutional framework and ways to realise the 'best' scenario. In this regard, the method could be extended to

include an institutional checklist that evaluates institutional factors that may support or hinder the realisation of a specific land use scenario.

5.5 Conclusions

The objective of this study was to test the applicability of the FoPIA method for the impact assessment of alternative land use scenarios in developing countries. The transfer of FoPIA to five cases with different regional contexts and land use problems generally worked well. The method proved suitable in diagnosing the causal relationships behind the regional land use problems and in improving communication among stakeholders. However, the actual impact assessment results were influenced by the participating stakeholders; a well-balanced group selection is recommended but could not be realised in all five regions. Therefore, the results of some regions may be biased and require a critical discussion. The optimal composition of the stakeholder group is subject to the assessment problem and often must be compromised due to the specific conditions on site. However, from our experience with the five cases, we conclude that a heterogeneous group of ten to twelve relatively well-educated participants, including land users, experts (preferably covering the three sustainability dimensions), and decision-makers, is advantageous both for the workshop atmosphere and the quality of the results.

Overall, FoPIA is suitable as a first-step assessment tool, but it cannot replace a comprehensive quantitative impact assessment and should, whenever possible, be accompanied by evidence from monitoring data or analytical tools.

Chapter 6

Methods and tools for integrated assessment of land use policies on sustainable development in developing countries

Abstract

For stimulating sustainable development in developing countries, land use patterns and land use changes are considered critical, and therefore effective and efficient land use policies are needed. In this paper we present a methodological framework that has been developed in a joint European and developing countries project (LUPIS - Land Use Policies and Sustainable Development in Developing Countries), to assess the impact of land use policies on sustainable development in developing countries. An illustrative application is presented for a case study in China, where water pollution due to agriculture in Taihu Basin is a major problem. We argue that an integrated assessment is required, considering multiple drivers and indicators that determine the objectives and constraints of the stakeholders involved. Therefore, the sustainability impact assessment (SIA) is based on the concept of Land Use Functions (LUFs), and impacts on these LUFs are discussed with stakeholders based on a multi-criteria analysis. LUFs comprise economic, environmental and social indicators relevant for stakeholders at multiple scales. Instead of focusing only on the indicators that determine the problem (e.g., nutrient leaching in the Chinese case study), we take a broader perspective (considering also social, economic and institutional objectives and constraints), such that feasible policy options can be recommended. Stakeholders have a large role in discussing the selection of indicators and policies (pre-modelling), evaluating the impacts on indicators (modelling), and the weighing of indicators and LUFs (post-modelling). For the assessment of impacts on indicators (modelling), quantitative and qualitative approaches are combined. We present and discuss an impact assessment of policy options in Taihu Basin, for the current situation and towards 2015. The methodological framework as presented here proved to be useful to guide a sustainability impact assessment in China and six other case study regions.

6.1 Introduction

To enhance sustainable development, various commitments and interventions have been implemented in the delineation (September 2000) and assessments (September 2005) of the Millennium Development Goals (MDGs). World leaders committed their nations to stronger global efforts for poverty reduction, universal education, woman's empowerment, health, environmental sustainability and development partnership. For promoting sustainable development in developing countries, land use patterns and land use changes are considered critical (e.g., Foley et al. 2005; Tilman et al. 2002; Turner et

al. 2007). Land reforms are vital for sustained productivity, food security, poverty alleviation, nature conservation and the environment (Bouma et al. 2007; Reid et al. 2005). Land use policies are thus key to the achievement of the MDGs (UN 2005).

The successful implementation of land use policies is often hampered by the fact that we do not know enough about their impact on sustainable development in different contexts. The potential role that land use policies could play is usually not assessed considering environmental, economic, social and institutional aspects in an integrated way (Kates et al. 2001; Kates and Dasgupta 2007; Reid et al. 2005; Robinson 2004; Wood and Lenné 2005). A range of research tools have been applied for sustainability impact assessment (Ness et al. 2007), but generic and flexible concepts and tools to perform policy impacts assessments, that allow an integrated analysis at multiple scales and can be applied and compared in different contexts in developing countries, are not available.

For an integrated assessment of the impact of land use policies on sustainable development, a systems approach is required (e.g., Ewert et al. 2009). The problems to be studied are highly complex as they relate to multiple scales, dimensions, sectors and stakeholders. At higher scale levels, computer simulation models, performing a comprehensive analysis of the land-use system, appear to be indispensable research tools (Bouma et al. 2007). This was acknowledged by the European Commission, who introduced Impact Assessment Guidelines and promotes the use of modelling tools to make policy development better informed and improve the quality of European policies (Bäcklund 2009; Commission of the European Communities (CEC) 2009; Thiel 2009). This resulted in a large number of studies on impact assessment of land use, policies and sustainable development (e.g., Binder et al. 2010; Boulanger and Brechet 2005; Hacking and Guthrie 2008; Rossing et al. 2007; Walter and Stützel 2009)

Policy analysis is typically concerned with a large unit of analysis, i.e. the regional or national level. Before the 1990s agricultural research was usually focused on the plot, field or farm level. In 1995, the Ecoregional Fund was initiated, with the aim of sponsoring methodology development projects in support of ecoregional research initiatives in various parts of the world (Bouma et al. 2007). This resulted in several successful studies, in which for example multi-objective programming was linked with GIS mapping to show the potential of agricultural activities in different locations (Roetter et al. 2005), and biophysical models were linked with econometric techniques to assess trade-offs between, for example, agricultural production and soil erosion (Stoorvogel et

al. 2004). Progress has thus been made, but thorough theoretical and empirical research into the effects of land use policies on the sustainable development of developing countries is still very much needed if we are to ensure the achievement of the Millennium Development Goals. Such understanding from assessments is vital to explore notions that, for example, the importance of trade is often underestimated (e.g., Dawe 2001), agricultural intensification can both lead to an increase (less area needed) and loss in biodiversity and ecosystem service provision (Glendining et al. 2009; Mooney et al. 2005; Reidsma et al. 2006), and intensification leads to soil mining (e.g., Smith et al. 2000).

Kates et al. (2001) argue there is an information gap between developed and developing countries. This leads to knowledge differences, which should be bridged by collaborations among developed and developing countries to discuss key questions, appropriate methodologies and institutional needs. Numerous studies have shown that investments in research and development typically rank first or second in terms of returns to growth and poverty reduction, along with investments in infrastructure and education (Von Braun et al. 2008). Besides collaboration between developed and developing countries, other requirements to improve sustainability science (Kates et al. 2001) are to connect to the policy agenda, and focus on nature-society interactions and the pathways that lead to sustainability considering these interactions.
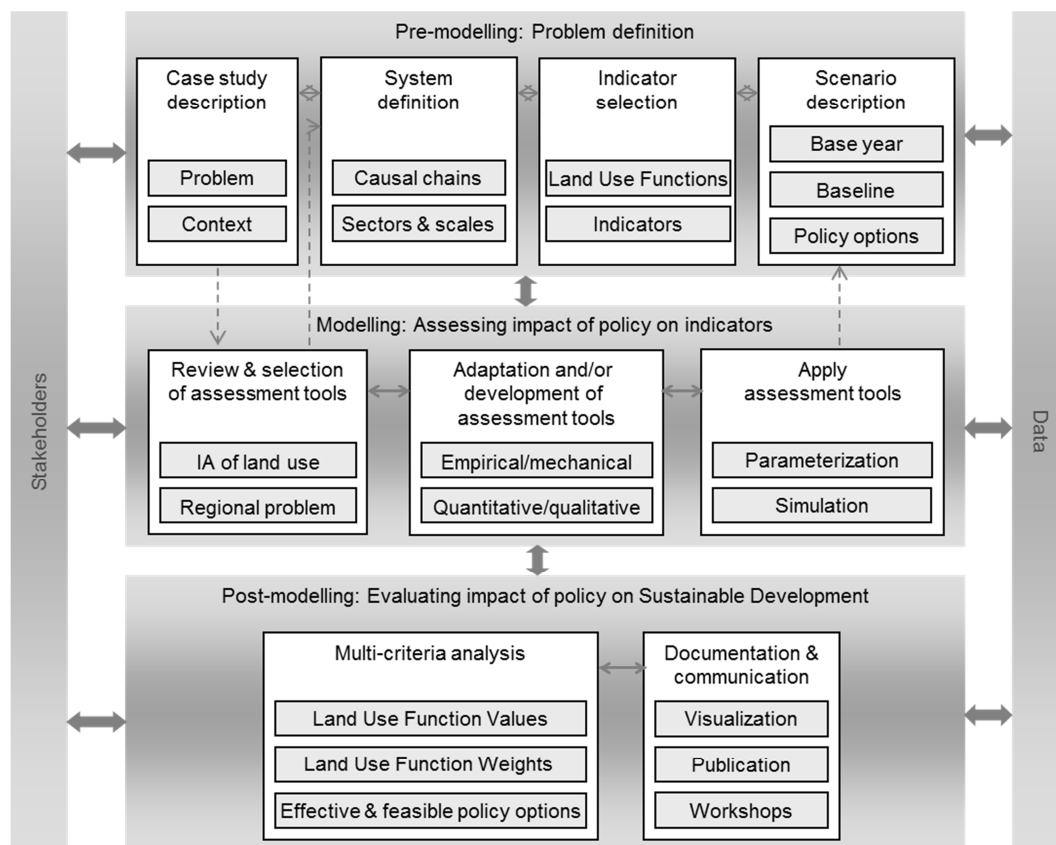
The aim of this paper is to present a methodological framework for sustainability impact assessment of land use policies in developing countries, considering the issues listed by Kates et al. (2001) above. The framework is multi-scale, integrated (economic, environmental, social and institutional) and involves stakeholders. Stakeholders include farmers, experts, policy-makers, researchers and other individuals, groups and organizations that are directly affected by decisions and actions or have the power to influence the outcomes of these decisions. Nine operational Land Use Functions (Pérez-Soba et al. 2008) are addressed to provide a holistic perspective. In the next sections we will present and discuss the methodological framework, and illustrate its applicability in a case study in Taihu Basin, China, where water pollution due to agriculture is a major problem. This paper focuses on presenting the approach while details of the case study modelling work are presented elsewhere.

6.2   Methodological framework

In the frame of a joint European and developing country project (LUPIS - Land Use Policies and Sustainable Development in Developing Countries), seven case studies have

been selected in seven developing countries (China, India, Indonesia, Brazil, Tunisia, Kenya, Mali) for performing ex-ante impact assessments of land use policies (Mc Neill et al. 2012). Each case study has its own specific land use problem, and each problem requires targeted land use policies. In order to assess these consistently, a methodological framework for sustainability impact assessment (SIA) has been developed that allows ex-ante assessments including (i) multiple land use sectors, (ii) multiple dimensions of sustainability, and (iii) multiple scales (Reidsma et al. 2008). The framework is meant to be generic and flexible, so that it can be applied across a range of issues and countries. It builds upon two complementary methodologies (SEAMLESS and SENSOR), developed in the European context, but has been enhanced and adapted to the context of developing countries. SENSOR (Sustainability Impact Assessment: Tools for Environmental, Social and Economic Effects of Multifunctional Land Use in European Regions; Helming et al. 2008) developed ex-ante impact assessment tools at regional scale for EU policies related to land use, with a focus on cross-sectoral trade-offs and sustainability side-effects. SEAMLESS (System for Environmental and Agricultural Modelling: Linking European Science and Society; Van Ittersum et al. 2008) concentrated on the agricultural sector and targeted at assessing agricultural and environmental policies and technological innovations at multiple scales. Using these two methodologies as building blocks, allows addressing a wide variety of land use problems, with a focus on agriculture, which is at the core of sustainable development in developing countries.

The SIA procedure has been adapted from the SEAMLESS methodology (Ewert et al. 2009) whereas the evaluation of sustainable development is based largely on the SENSOR approach (Helming et al. 2008; Pérez-Soba et al. 2008). The SIA procedure is subdivided in three main phases (Figure 6.1), a pre-modelling phase (problem definition), a modelling phase (assessing the impacts of policies on indicators) and a post-modelling phase (evaluating impact of policies on sustainable development). Modelling is at the core of the framework and refers to computer-based models, but also includes qualitative approaches. Ex-ante impact assessments require models (whether quantitative or qualitative) that can give forecasts for the future.

Figure 6.1. Methodological framework for sustainability impact assessment (SIA) of land use policies in developing countries. The whole framework is iterative as mentioned by the two-way arrows. Where specific iterations are required, extra (dashed) arrows are included.

Involving stakeholders in the SIA is important to understand the regional and local problems and constraints, build trust, and have impact on policy making processes (Bouma et al. 2007; Giller et al. 2008; Lebel et al. 2006; Van Paassen et al. 2007). Part of the framework is therefore to organize policy fora with stakeholders in each phase of the process. In the pre-modelling phase discussions focus on problem identification, selecting relevant indicators and selecting policy options that have the potential to reduce the problem and improve sustainable development. In the modelling phase the stakeholders are approached to provide expert knowledge on driver-impact relationships and expected changes in indicators according to scenarios. In the post-modelling phase the main aims are to discuss the modelling results and assign weights to indicators in the multi-criteria analysis (MCA).

Although pre-modelling is logically performed before modelling, performing a SIA is an iterative process requiring refinement throughout the process, as indicated in Figure 1 by

the arrows. In the following sections we will describe each phase of the SIA, using the Chinese case study as an illustration.

6.3 Pre-modelling

6.3.1 Case study description

Problem definition

A major land use problem in China is the water pollution due to agricultural sources in Taihu Basin. Taihu is one of the five major lakes in China. It is a well-known place for tourists with beautiful lake and mountain landscape views. It also serves many other purposes, such as a source of drinking water, storage of flood water, shipping, irrigation and aquaculture. Due to rapid economic development in Taihu Basin since the 1980s and the lagging environmental protection, the water quality of major rivers running into the lake and the lake itself is now seriously polluted (Jin et al. 2006). Industry, domestic sewage and agriculture are the major sources increasing nutrient levels of the rivers that run into Taihu. It is expected that due to the internal restructuring of industry and the production processes in China, emissions from industries will continue to decline. Pollution from domestic sewage is being reduced by wastewater treatment plants. Agricultural non-point sources are projected to continue growing for a long time, because they are extensive and complex to manage, and governments have limited control (Zhang et al. 2001).

Context

Taihu Basin is located in the east of China, between the end of Yangtze River and the Qiantang River and Hangzhou bay (Figure 6.2). Taihu Basin crosses through three provinces and one city, which are Jiangsu province, Zhejiang province, An-hui province and Shanghai city. Its total area is 36,500 km^2. Taihu Basin is an agriculturally productive and economically important region in China. The land area of Taihu Basin comprises 0.4% of China, population is less than 3%, but the GDP accounts for 12% of China. Population density is high, with 1,100 inhabitants per km^2. It is a subtropical region, with an average temperature of 14.9-16.2°C, July having the highest temperatures (27.7-28.6°C) and January the lowest (1.7-3.9°C). Mean annual precipitation is 1010-1400 mm, gradually increasing from north to south. Although agriculturally productive, agriculture has only a small share in the GDP (2.8%), mainly due to high economic growth in the last decades.

Figure 6.2. Map of Taihu Basin, China.

Besides reviewing the geographic, socio-economic and environmental context, we gave specific attention to the policy and institutional context. The policies currently in place and their effectiveness determine feasible policy options for the future. A land use policy typology was developed that distinguishes between objectives of the policies (Bonin et al. 2009). For Taihu Basin, twelve resource oriented, six sectoral and four integrated polices were identified and reviewed (Feng et al. 2012). The common purpose of most of the policies characterized as resource oriented in Taihu Basin is the appropriate development, utilization and protection of water and soil resources. These include the "Zero-clock Action", which was implemented in 1998 by the State Environmental Protection Bureau, and initiated integrated pollution control in Taihu. After that, several regulations on reducing water pollution have been implemented at national, provincial and basin level. Most resource oriented policies have not yet achieved their goals, because they were mainly formulated to deal with the consequences of the pollution, and not with the actors

who cause the pollution. The purpose of the sectoral policies is mainly to reduce environmental pollution from agriculture (e.g., pesticide control, ecological agriculture). Important for the development of agriculture are the five-year plans; for 2006-2010 this was the 11th five-year plan for the construction of modern agriculture in Jiangsu province (2006-2010). Goals are ambitious, but due to lack of implementation and dissemination, the awareness on the need for environmental protection is still low. Integrated policies include land use planning at provincial, town, and country level, which are generally formulated to support economic, environmental and social development jointly. In general we observed that many policies have been formulated, but that lack of implementation, dissemination and monitoring prevent achieving the targets.

6.3.2 System definition

Causal chains

Within the methodological framework for SIA other frameworks were used for specific steps. The Driver, Pressure, State, Impact, Response (DPSIR) framework was used to analyse the causal relationships between the various economic, environmental, social and institutional aspects of the situation (Helming et al. 2008; OECD, 1993). Figure 6.3 gives a summary overview including an example for the Chinese case study. This example includes iterations with the remaining steps in the pre-modelling phase (Figure 6.1); the identified causal chains provide a good basis to define the most relevant scales & sectors, indicators and policy options.

Proximate drivers (Geist and Lambin 2001) of land use change and associated impacts on water pollution are agricultural intensification and demand for food. Together these determine the demand for agricultural land and how this is managed (Pressure). Industrial pollution and domestic sewage are also proximate drivers of the problem; the contribution of agriculture to water pollution should be seen in context of these sources. Changes in these proximate drivers are influenced by underlying drivers such as economic development, technological development and population growth, and by policy and institutional factors. Land use and land use intensity do not influence sustainable development as such, but they affect the state of relevant social, environmental and economic indicators, including nitrogen (N) leaching, farmers' income and labour use. The impacts on sustainable development are measured by thematically grouping them

into Land Use Functions as further explained in section 6.3.3. Based on the causal chain analysis, feasible policy options (responses) can be identified.
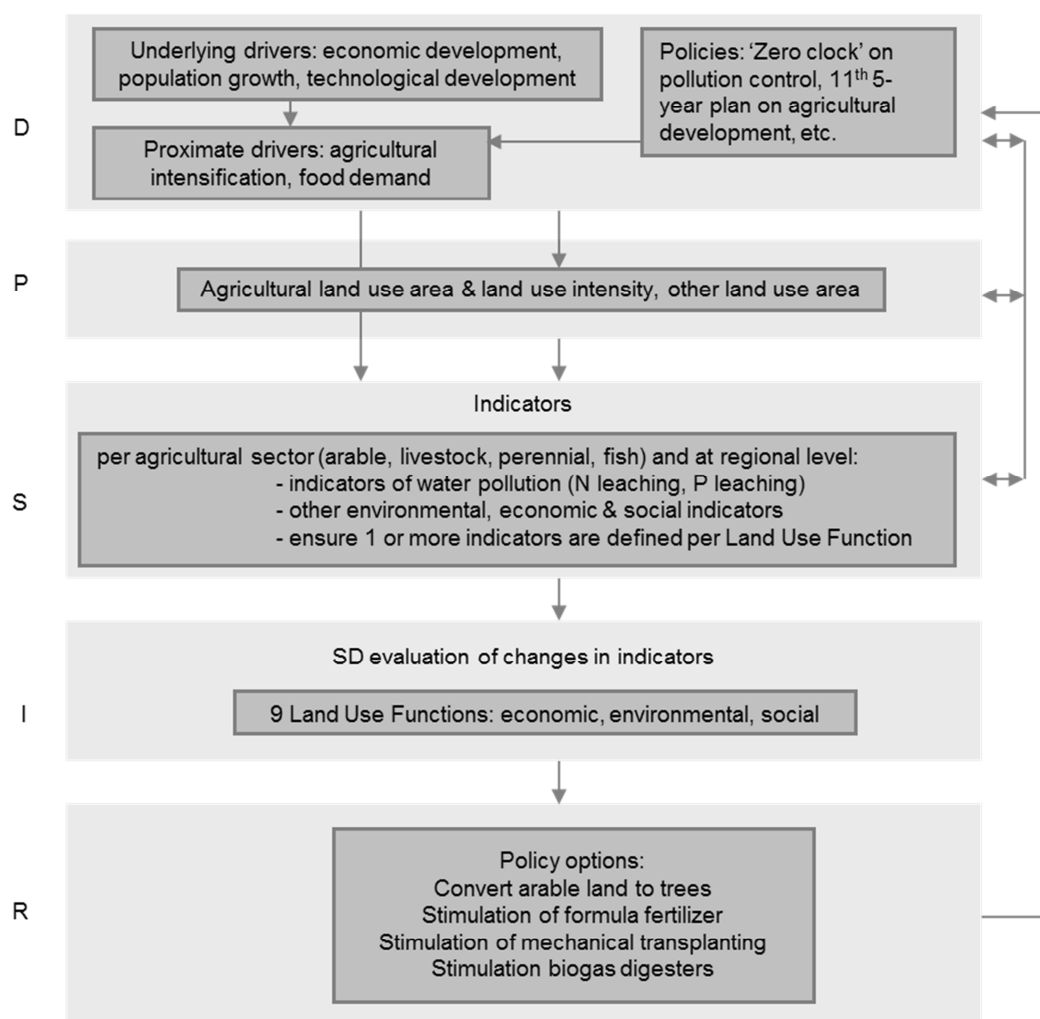
Figure 6.3. Summary of the causal chain analysis of the Chinese case study using the Driver-Pressure-State-Impact-Response (DPSIR) framework. The causal chains of the problem 'water pollution due to agriculture' are identified. The State indicators are the most important indicators per Land Use Function, which are used to evaluate the Impacts. To clarify linkages between indicators and Land Use Functions, these are detailed in Fig. 6.5. Considering the review of causal chains DPSI, feasible policy options relevant for ex ante assessment are identified as Responses. In the ex-ante assessment, these will also be considered as drivers. As relationships are not one-directional, but feedbacks occur between Drivers, Pressures and Indicators, and direct relationships exist between Indicators, extra arrows are included.

The arable sector has the largest contribution in N leaching and run-off to surface water towards Taihu. Grontmij (2005) estimated a contribution of 58,200 tons/yr from paddy and dryland fields compared to 5,500 tons/yr from livestock and 2,600 tons/yr from fish

farming. The contribution to phosphorus (P) load was estimated to be small (around 0) compared to livestock (1,250 tons/yr) and fish (300 tons/yr), but experiments show that due to long-term high P application and extreme rainfall events, the arable sector also contributes to P losses

(Cao and Zhang 2004; Guo et al. 2004; Xie et al. 2004). To improve water quality, it is essential to reduce emissions of both nutrients. As the lake is currently P limited, in the short-term the reduction of P emissions is more effective than the reduction of N. However, as P emissions from industry and domestic sewage have largely been reduced already due to effective policies, in the longer-term reducing N becomes more important. Clearly, N and P leaching are important indicators, but land use and intensity change also affect other indicators of sustainable development, such as crop production, food security, farmers' income, labour use and biodiversity. Using the DPSIR, most relevant indicators (State) and Land Use Functions (Impacts) were selected, which is further explained in section 6.3.3.

Sectors and scales

The main land use sector that was assessed is the agricultural sector. Earlier studies have performed a more general assessment, estimating the relative impact of agriculture (Grontmij 2005; Yang and Wang 2003); here we go into more detail to search for effective and feasible policy options. Therefore different agricultural sectors were distinguished: arable, perennial, livestock and fish. In this paper we focus on the arable sector.

Water pollution is worst in North-west Taihu Basin, due to the direction of river flow and the large agricultural land area in this part. The regional assessment is therefore restricted to this area (Figure 6.4), and is further divided into three municipalities (Wuxi, Changzhou and Zhenjiang). Within the municipalities and per agricultural sector, farm types are distinguished. For the arable sector 320 farms have been surveyed and cluster analysis is used (Köbrich et al. 2003), obtaining 4 farm types differing in farm size and contribution of off-farm employment to household income (influencing labour and capital availability). Farm types can choose among different agricultural activities, which are defined as rotations with a certain technology on a soil type. There are clay, loamy and sandy soil types observed in the Basin with the majority of farms operating on clay soils (57% of area of surveyed farmers). As the assessments for different sectors and at

different scales are extensive, in this paper we present the assessment at agricultural activity level (i.e., field). Results at this level form the basis for higher level results. Rice-wheat is the major rotation (90% of the area of surveyed farmers). The technologies in Figure 6.4 relate to the policy options.
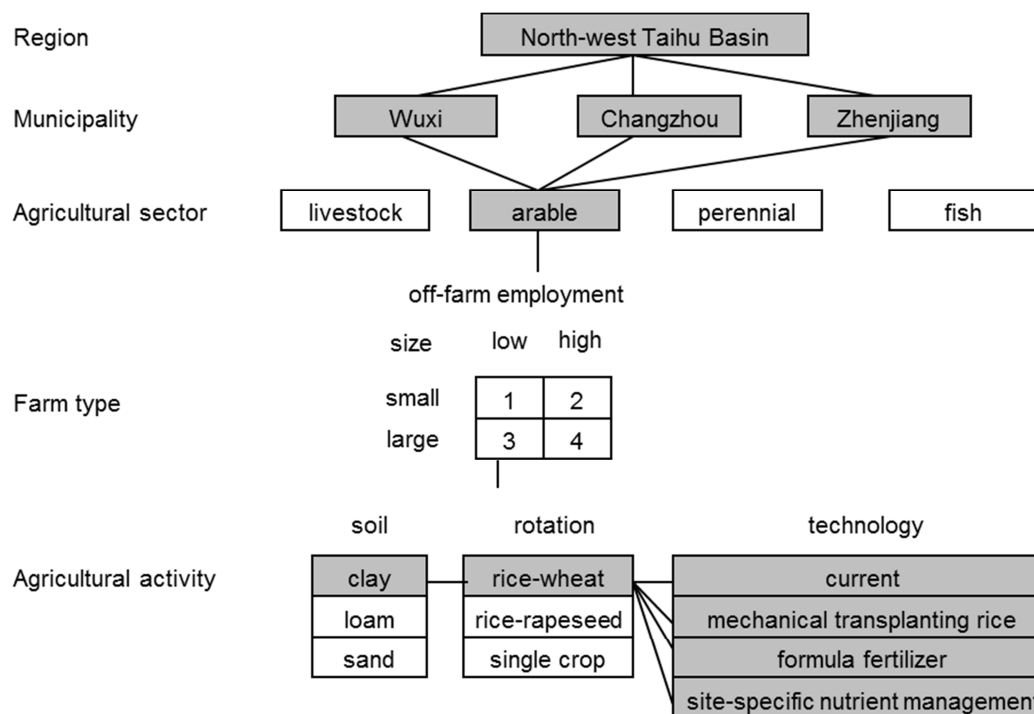

Figure 6.4. Scales and land use sectors assessed in the Chinese case study. The boxes addressed in this paper are highlighted in grey.

6.3.3 Indicator selection

In order to translate a notion of sustainable development into a balanced set of indicators (Alkan Olsson et al. 2009), an indicator framework has been developed. The LUPIS indicator framework builds upon the concept of Land Use Functions (LUFs), as developed by Pérez-Soba et al. (2008). Nine LUFs are identified, i.e., three per dimension (i.e., economic, environmental and social), that represent regional sustainability in an integrated way. LUFs illustrate most relevant sustainability issues and are defined as goods and services associated with land use (e.g., economic: land-based production; environmental: maintenance of ecosystem processes; social: provision of work/livelihood). They refer to regional preferences with regard to the functionality of the land and therefore to the extrinsic value of the land. LUFs are a pragmatic way for stakeholder-driven sustainability assessment of land use changes (Schößer et al. 2010).

Figure 6.5 illustrates the LUPIS indicator framework, which we explain here starting with clarification of Sustainable Development (SD) targets in Taihu Basin, which direct towards most relevant LUFs and result in a selection of indicators per LUF. LUFs can comprise multiple indicators (Paracchini et al. 2011), but as aggregation is not straight forward and presentation is not transparent, for this paper we select one indicator per LUF.
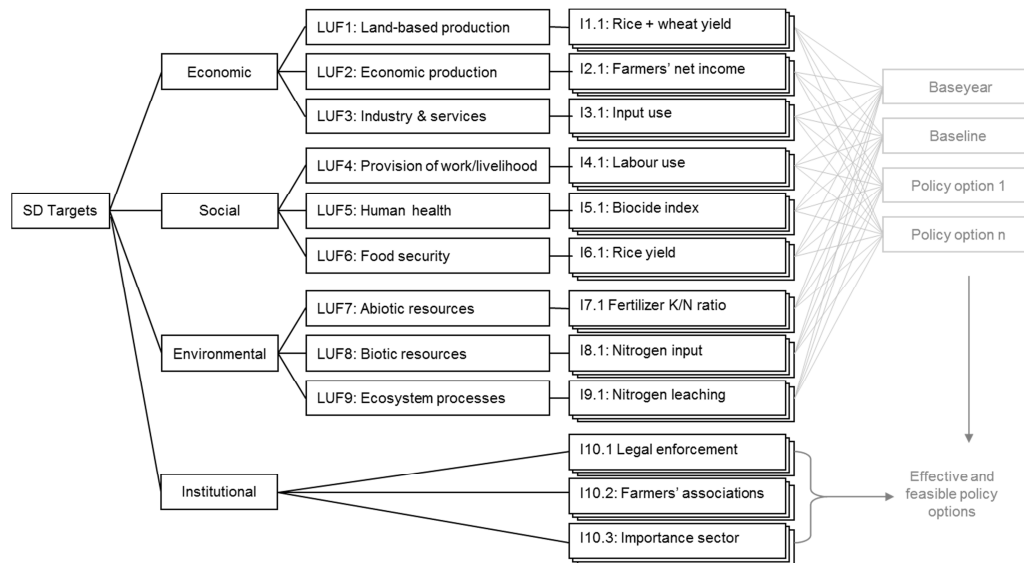
Figure 6.5. The indicator framework for sustainability impact assessment (SIA) using Sustainable Development (SD) targets, Land Use Functions (LUF) and indicators. All environmental, economic and social indicators are assessed for different scenarios, and combined with institutional indicators, these assess the feasibility of policy options (in grey). Selected LUFs and indicators at field level in Taihu Basin, China, are presented.

For 2010, environmental policy targets were to reduce the use of pesticides and nitrogen (N) by 30% and 20%, respectively (Feng et al. 2012). The agricultural emission of total N and total phosphorus (P) to the lake should have reduced at least with 50%. New policy plans towards 2015 will likely further strengthen these targets. In 2015, water quality should reach class III (the concentration of COD and NH3-N should be below 20 mg/l and 1.5 mg/l). These targets mainly refer to the environmental LUF 'maintenance of ecosystem processes'. N leaching, which was identified as an important indicator in section 6.2.1, was selected to represent the LUF 'maintenance of ecosystem processes'. P leaching is also an indicator of this LUF, and impacts can additionally be presented, but we prefer not to aggregate these two indicators. The LUF 'maintenance of ecosystem processes' is supported by abiotic and biotic resources. As the application of N fertilizer

compared to P and especially potassium (K) has been too high in the last decades (based on Janssen and de Willigen (2006), Tian et al. (2007) and own data), reducing the contribution of N compared to K will improve the ideal soil fertility (the main reason to introduce 'formula fertilizers') and hence the LUF 'abiotic resources'. Lastly, the N input can serve as an indicator for biodiversity loss and hence the 'biotic resources' (Asai et al. 2010; Kleijn et al. 2009). Maintaining biotic resources is an important LUF to ensure sustainable development, and therefore this should be addressed. Impacts on N inputs can additionally provide insights in reasons for changes in N leaching.

The main economic targets aim to increase the production of rice and other products, to increase the income of rural households, and to reduce the rural-urban income gap (Feng et al. 2012). These are related to the LUFs 'land-based production' (rice+wheat yield), 'economic production' (net income) and 'industry and services' (input use). Although a high input use is not necessary positive, money spent on machinery, fertilizers, pesticides and other inputs does represent the stimulation of other business activities. Social targets aim to ensure food security, a healthy environment including safe drinking water, and the provision of work/livelihood to the rural households. These were related to the indicators rice yield, a biocide residue index (Ponsioen et al. 2006) and the labour use. As off-farm employment gives higher profitability than agriculture, a reduction in labour use was considered positive.

The impact of a policy on sustainable development can be assessed based on environmental, economic and social indicators. Whether a policy is likely to be implemented, monitored and successful, also depends on the institutional context or governance. Governance includes laws, regulations, discursive debates, negotiation, mediation, conflict resolution, elections, public consultations, protests, and other decision-making processes (e.g., Lebel et al. 2006). As the institutional context is cutting across the three dimensions of sustainable development, its assessment is different and therefore often omitted. In our framework the ability to implement policies is important in the review of the policy and institutional context and the selection of policy options in the pre-modelling phase, and in the SD evaluation in the post-modelling phase. Institutional indicators can be defined to assess (quantitatively or qualitatively) the ability to implement policies (Theesfeld et al. 2010), and hence the impact of a policy on SD targets. The review of the institutional context showed that implementation and monitoring of policies in the case study area should be strengthened, which can be

measured by the indicator 'law enforcement'. Also public awareness and participation should be improved, which can be related to 'membership in farmers' associations'. Another important indicator is the economic importance of the agricultural sector, which influences the willingness to use economic instruments such as subsidies and taxes. Theesfeld et al. (2010) present ways of quantitatively measuring such indicators using data from f.e. the World Bank. In this study we judged these indicators qualitatively based on the policy review.

6.3.4 Scenario description

Current situation

A farm survey has been held on 320 arable farms, in 16 different villages in the 3 municipalities in 2008, which is considered as the base year. Data on cropping patterns, input use, technologies, outputs, objectives and constraints which are relevant to assess the selected indicators were collected. These data were complemented with soil and climatic data from regional sources. For the base year scenario the available data are used to assess a conventional rice-wheat rotation on clay (2008 BASE).

Baseline scenario

The target year for ex-ante assessment is 2015. For policy makers and other stakeholders this short time horizon is relevant, as it directly links to current policies. For an assessment of sustainable development in the longer term it is relevant to have a more distant horizon to complement the assessment (e.g., 2025), but forecasts will be more difficult to validate. When the focus of the analysis is on the impact of policies, these should be evaluated against a baseline, a so-called 'business-as-usual' scenario where currently observed trends persist in the future. The DPSIR framework presented in Figure 3 helps to shape the scenarios. For the arable sector in Taihu Basin, trends in crop yields, input and output prices and subsidies were estimated based on historical trends. These were used to forecast how a conventional rotation of rice-wheat on clay (2015 BASE) will perform in the baseline scenario.

Policy options

In the case study definition and case study description, relevant policies and their impacts have been reviewed. Based on this review of policies, and discussion with stakeholders,

policy options that have the potential to improve sustainable development towards 2015 are identified and specified. Three policy options have been selected that (i) have potential to reduce water pollution, (ii) have impact on sustainable development at large, (iii) have been adopted already by farmers and implementation is therefore plausible and (iv) can be simulated with the models selected (therefore iterations with the modelling phase are needed; Figure 6.1).

The first policy option refers to the stimulation of the use of what locals call 'formula fertilizers', generally known as site-specific nutrient management (SSNM). Based on soil samples and nutrient balance calculations, extension officers give site specific recommendations on nutrient management (Dobermann et al. 2002; Wang et al. 2007). A better formula for fertilizers and a better timing will reduce nutrient pollution, and may also have positive side-effects on crop yields and net income. To assess the impact of this policy in the base year 2008, we firstly assessed the rice-wheat rotation on clay with SSNM as currently applied by farmers using formula fertilizer according to average data (2008 FF). Secondly, optimal SSNM aiming for a zero nutrient balance as advocated by research (2008 SSNM) was assessed. This has not been observed much in practice yet. The 2015 FF gives a projection if policies with regard to improved nutrient management are continued as currently applied. The rotation with SSNM (2015 SSNM) presents what is feasible in terms of crop yields and nutrient losses according to experiments (Jing et al. 2007).

The second policy option relevant for arable farming is the stimulation of mechanical transplanting. Mechanical instead of hand transplanting of rice does not directly reduce nutrient leaching, but improves labour use efficiency, which is important in this region with increasing labour costs; it can thus facilitate adoption of SSNM. It furthermore reduces land use for seedbed and pesticide use, and increases yields. For the base year, this scenario was based on average data and current subsidies (2008 MT), the 2015 MT refers to stimulation of mechanical transplanting of rice fully subsidizing the rent of machinery use.

The third policy option considers the conversion from arable land to trees in areas close to rivers and the lake. Farmers who have land in these areas get compensation payments, but cannot grow crops anymore on these lands. These riparian buffer zones can reduce nutrient leaching, but will also influence the income and livelihoods of farmers.

6.4 Modelling

6.4.1 Review and selection of assessment tools

Tools for sustainability impact assessment were categorized by Payraudeau and Van der Werf (2005) and Ness et al. (2007), including ex-post approaches based on empirical data, and ex-ante approaches based on modelling. For ex-ante assessment, the generic approaches developed in the European context in the SEAMLESS (agriculture, multi-scale) and SENSOR (land use, regional) projects, can be used as a starting point. Although these generic approaches provide a basis for SIA in developing countries, the selection of models depends on the case study objectives. The models should allow assessment of the identified causal chains between drivers, policies and indicators as identified in the pre-modelling phase. As each land use problem involves different drivers, policies and indicators, we did not develop a modelling framework, but a framework that allows selecting appropriate models and approaches. Table 6.1 gives an overview of methods that have been applied in the case study in Taihu Basin, China. The Table includes models at other scale levels and for other agricultural sectors to which results presented here are linked in order to assess the relative contribution to water pollution in Taihu.

Table 6.1. Models used for sustainability impact assessment of land use policies in Taihu Basin, China.

Model type	Agricultural Sector	Scale	Classification[a]	Reference (e.g.)	Indicators (e.g.)
Ex-post					
Econometric/ Regression models	Arable Livestock	Farm Region	Quantitative Empirical	Liu and Wang (2005)	Fertilizer use Adoption of environmentally friendly technologies Fertilizer use efficiency Animal waste management
Ex-ante					
Technical Coefficient Generator	Arable Perennial	Field	Quantitative Mechanistic	Ponsioen et al. (2006)	Crop yield N leaching Net income
Bio-economic model	Arable	Farm type	Quantitative Mechanistic	Louhichi et al. (2010) Janssen and Van Ittersum (2007)	Land use pattern Crop production N leaching Farm income
Response functions using DPSIR	Livestock Perennial Fish Arable	Agricultural sector	Quantitative Empirical	Sieber et al.(2008): mainly based on quantitative information	Indicators not included in other models used, but for which quantitative data are available
Knowledge rules using DPSIR	Livestock Perennial Fish Arable	Agricultural sector	Qualitative Empirical	Sieber et al.(2008): mainly based on qualitative information	Indicators for which no quantitative data are available

Note: The classification refers to research approaches as presented in Bouma (1997) and Stoorvogel and Antle (2001). Qualitative methods refer to stakeholder and expert knowledge, while quantitative methods refer to data analysis and modelling. Empirical methods are based on data analysis, while mechanistic methods are based on process-based models.

6.4.2 Adaptation and/or development of assessment tools

When models are claimed to be generic, this does not imply that they can be readily used to assess indicators. When a specific model is used for another type of application or in another context, data needs to be collected as input in the model and often adaptations to the model structure need to be made. A bio-economic farm model was used to assess the impact of policies on farm performance in the arable sector, based on the Farming Systems SIMulator (FSSIM) developed in SEAMLESS (Louhichi et al. 2010). FSSIM is a generic model that can also be used outside the European context. However, although the generic structure is re-usable, several components needed to be adapted to the Chinese context. This can partly be done by using models and insights from similar regions. Models developed for a neighbouring region, Pujiang, are used to adapt regional agricultural structure (e.g., Hengsdijk et al. 2007; Van den Berg et al. 2007). For example, instead of rotations having one crop each year as in Europe, in Taihu Basin, rotations include multiple crops within one year.

A major requirement as input into bio-economic models, is the quantification of agro-ecological relationships. For this, we used the Technical Coefficient Generator developed for South-East Asia, TechnoGIN (Ponsioen et al. 2006). TechnoGIN simulates input-output relationships of agricultural activities on a hectare basis. TechnoGIN was adapted to serve as a technical coefficient generator and at the same time as a database hosting all the necessary input data for FSSIM. Farm survey data was used together with other data from literature and expert knowledge to feed TechnoGIN and FSSIM. Statistical analyses were performed on the data to ensure reliability, and to empirically analyse relationships between for example education and fertilizer use (e.g., Che 2009).

Other agricultural sectors, including livestock, perennial and fish farming, have been assessed using response functions and knowledge rules (Sieber et al. 2008), constructed on the basis of available data and econometrically quantified relationships.

6.4.3 Application of assessment tools

An integrated assessment requires the application of multiple tools at multiple scales. In this paper it is not feasible to describe all tools, assumptions and results. As an example, we present the model application at field level using TechnoGIN, which is at the basis of results at farm and regional level. TechnoGIN was applied for each agricultural activity,

including different rotations, soil types and technologies in line with the policy options. The rice-wheat rotation on clay soils is presented, for which average data on inputs and outputs (on f.e. crop yields, fertilizer use) from three municipalities was used (Kang 2009; Van Loon 2010).

When assessing current activities including 2008 BASE, 2008 FF and 2008 MT, the data collected on nutrient application and obtained yields served as inputs, while TechnoGIN calculates nutrient losses (leaching and run off, denitrification, volatilization, fixation) using the built-in model QUEFTS (Janssen et al. 1990). When assessing alternative activities aiming for optimal nutrient management (2008 SSNM), the yearly fertilizer applications are calculated by balancing the inorganic and organic nutrient pools, so that the fertilizer applications and target yields can be repeated for many years without mining the soil or building up a soil nutrient reserve. Other indicators (Figure 6.5) are calculated based on data collected on input requirements, input costs, crop yields and output prices. For 2015 BASE, 2015 FF and 2015 MT it was assumed that nutrient applications stay constant while yields increase according to historical trends. For 2015 SSNM it was assumed that with training and education the highest yields obtained in experiments and by farmers, can be obtained by the average farmers, while nutrient requirements are calculated by the model.

6.5 Post-modelling

6.5.1 Multi-criteria analysis

Land Use Function values

In the post-modelling phase, the changes in indicator values associated to the corresponding LUFs for the different scenarios were evaluated for (i) the impact on the problem, and for (ii) sustainable development in the wider context. In Figure 6.6, results from the modelling example (section 6.4.3), conventional rice-wheat rotation on clay, are presented for 9 indicators linked to Land Use Functions for the base year (2008 BASE), and % change relative to 2008 BASE for the policy stimulating the use of formula fertilizer (2008 FF), the potential of a policy improving site-specific nutrient management (2008 SSNM), and the policy stimulating mechanical transplanting of rice (2008 MT). The +/– indicates whether an increase was considered positive or negative; accordingly an increase in the area of the spider diagram indicates a positive influence on SD. Figure 6.7 presents the projections towards 2015.

In Figure 6.6 it can be observed that in 2008, farmers that were stimulated by the policy to apply formula fertilizers (FF) changed the K/N ratio of fertilizers, but they did not reduce total N input (farm survey data) and therefore N leaching was not reduced compared to the conventional application (simulated). The indicator for abiotic resources thus improved (contribution of N:P:K in fertilizers was more in line with what is needed considering the soil), but this was not associated with lower values of indicators representing biotic resources and ecosystem processes. With improved SSNM considering the same target yield, TechnoGIN shows that the contribution of K relative to N in fertilizers can be further increased (+38%), while total N, P and K input should be reduced, resulting in considerable lower impacts on the environment (80% less N input and 86% less N leaching). The impact of mechanical transplanting is mainly in the reduction of labour use, leaving more time for off-farm employment (or to improve nutrient management).

In the current situation, according to the farm survey data on average 25% of the farms use formula fertilizer (FF) of which only a minor fraction applies it according to principles of SSNM, while 31% of the farmers use mechanical transplanting. The sustainability at farm and regional level depends on the results as presented in Figure 6 and the degree to which a certain agricultural activity is adopted. Considering that rice-wheat on clay is the major agricultural activity, we can conclude that average indicator values at regional level are close to the ones presented for BASE 2008. The bio-economic farm model gives more details on diversity at farm type level (not shown).

The average net income of 8607 yuan/ha is more than the compensation payments for the buffer zones in Wuxi (6750 yuan/ha) and Changzhou (7500 yuan/ha), but lower than what farmers receive in Zhenjiang (9000 yuan/ha). Buffer zones are said to reduce N and P leaching with more than 80% (e.g., Klok et al. 2002) and are therefore effective to reduce water pollution, but whether the compensation payments cover the income loss of the farmers, depends on the municipality and the individual performance of the farmers.

When looking ahead towards 2015 (Figure 6.7) for improved SSNM (2015 SSNM) rice yields can increase to 10 tons/ha. Higher crop yields require more N inputs (twice as much as 2008 SSNM, but still half of 2008 BASE), but as these will mainly be taken up by the crops, N leaching is low. The only negative impact is on labour use (i.e., more labour is required), reducing time available for off-farm employment. As mechanical transplanting reduces labour use, combining both technologies may be the best option

having positive impacts on environmental and economic LUFs, and also being socially feasible for the farmers. However, for 2008 mechanical transplanting (2008 MT) results on average in less profit than hand transplanting (-2%, Figure 6.6). With completely subsidizing machinery (2015 MT) net income can be increased (+20%, Figure 6.7).

Land Use Function weights

Comparing indicator values and their trade-offs is one part of a multi-criteria analysis (MCA) (Saaty 1980). A second part is to give weights to the different indicators/LUFs, given the preferences of stakeholders and expert knowledge. Normalizing LUFs and aggregating them using weights defined by stakeholders, summarizes multiple indicators into single scores, thereby indicating which scenario scores best. It can be argued that all LUFs should have the same weight, but the different preferences of stakeholders can influence the feasibility of a policy option to be implemented. Researchers, government officials, extension officers and farmers in Taihu Basin discussed the SD dimensions, considering the LUFs and associated indicators, and attributed weights for their importance in the region. Although the weights of the three dimensions were similar, different stakeholders had different views on the importance. Summarized, according to researchers the ranking was social (36%) > economic (33%) > environmental (31%); government officials and local extension officers thought that the sequence should be economic (50% and 45%) > environmental (33% and 35%) > social (17% and 20%); and according to farmers it should be environmental (37%) > social (33%) > economic (30%). It showed that all stakeholders are aware of the multiple land use functions of agricultural land use, and that besides food production, also LUFs like provision of work and ecosystem processes are considered important. The high importance researchers gave to the social dimension was mainly due to the weight given to food security, which is important at regional level. For farmers, this is less important as they are not dependent on food produced on-farm. Farmers gave a high importance to the environmental dimension, which was largely due to weights given to the indicators biocide use and (aquatic) biodiversity. They were unaware of the impacts of their own management practices on nutrient leaching and did not consider N and P leaching important for (aquatic) biodiversity.

A full MCA is mainly interesting for discussions with stakeholders. It reveals the understanding of stakeholders on indicators and may improve this. Caution should however be taken with presenting results as scientific, as the reliability depends on this

understanding, and the stakeholders selected. Furthermore, for deriving a single score per scenario, indicators should be normalized considering their targets and thresholds (Paracchini et al. 2011). These are generally difficult to establish. They can be based on policy targets, ecological thresholds, general trends and expert knowledge. Which value is considered as sustainable determines the normalized indicator and hence the importance for the SD evaluation. Nevertheless, as Rockström et al. (2009) argue, even though uncertain, especially for environmental indicators it is important to estimate the safe operating space, i.e., the thresholds between which we can operate. Although in 2015 SSNM the 74% decrease in nitrogen leaching may seem to have more impact than the 19% increase in labour requirements, the latter has more impact on SD at farm level and is hence a reason not to adopt SSNM (although environmental LUFs were given most weight, thresholds for social and economic LUFS often appear to be tight). If at regional level reducing nitrogen leaching is considered to be important for SD, policies are required that also consider labour requirements. Due to the uncertainty, we do not present a scientific exercise here, but will further discuss the indicator values, weights and targets and thresholds with stakeholders.

Effective and feasible policy options

Concluding on the effectiveness and feasibility of the policy options based on Figure 6.5, 6.6 and 6.7, we can write that creating buffer zones is an effective policy, as legal enforcement is high, effects on reducing N and P leaching to water bodies are high, and compensation payments are good compared to the average net income. Other indicators (Figure 6.5) were not specifically assessed for this policy option, as these are all zero at the field level (i.e., in buffer zones there is no fertilizer, biocide and labour input, and no crop production). Legal enforcement is more difficult for changing technologies such as SSNM, which is exemplified by the 2008 FF scenario. More education and training is needed to optimize SSNM, which should be organized by farmers' associations and extension services, while legal enforcement may be improved by recording amount and timing of nutrient management as done in for example the Netherlands. Mechanical transplanting is not always profitable, so providing more subsidies would help farmers to use the machines. As it is important for the government to keep up rice production and in the meantime to reduce the rural-urban income gap, providing more subsidies seems to be a solution.

| SD dimension	Land Use Functions	Indicator	Unit	2008 BASE	
Environmental	Abiotic resources	Fertilizer K/N ratio	kg K/kg N	0.20	+
	Biotic resources	N input	kg N/ha	634	−
	Ecosystem processes	Nitrogen leaching	kg N/ha	133	−
Economic	Land-based production	Rice + wheat yield	tons/ha	12.0	+
	Economic production	Net income	yuan/ha	8607	+
	Industry & services	Input costs	yuan/ha	11543	+
Social	Provision of livelihood	Labour use	days/ha	258	−
	Human health	Biocide index	-	641	−
	Food security	Rice yield	tons/ha	7.0	+
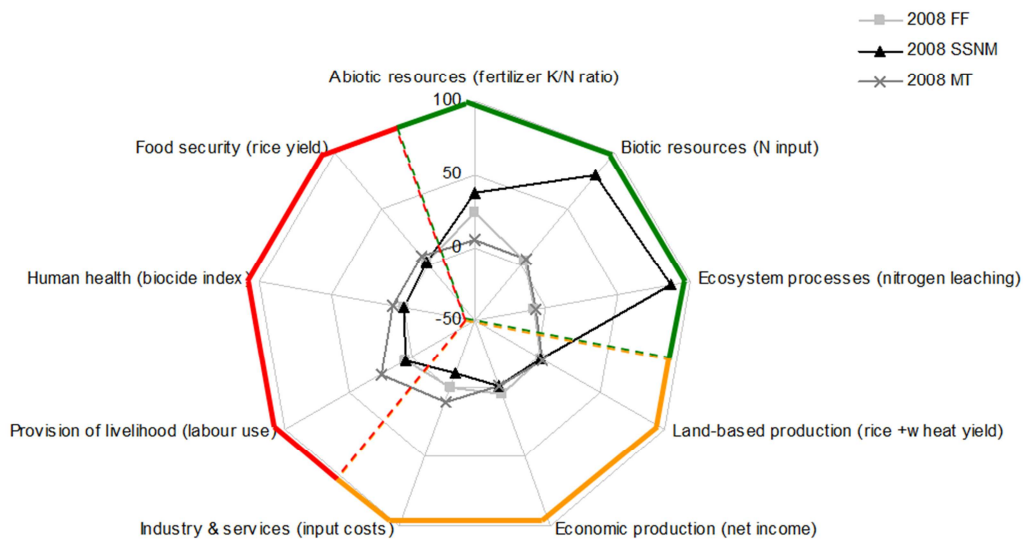
Figure 6.6. Modelling results for 9 indicators linked to Land Use Functions for a conventional rice–wheat rotation on clay at field level using TechnoGIN in the base year (2008 BASE), and % change relative to 2008 BASE for the policy stimulating the use of formula fertilizer (2008 FF), the potential of a policy improving site-specific nutrient management (2008 SSNM), and the policy stimulating mechanical transplanting of rice (2008 MT). The +/− indicates whether an increase was considered positive or negative; accordingly an increase in the area of the spider diagram indicates a positive influence on SD. To show the different impacts on environmental (green), economic (yellow) and social (red) LUFs, these are distinguished by colour. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

| SD dimension	Land Use Functions	Indicator	Unit	2015 BASE	
Environmental	Abiotic resources	Fertilizer K/N ratio	kg K/kg N	0.20	+
	Biotic resources	N input	kg N/ha	634	−
	Ecosystem processes	Nitrogen leaching	kg N/ha	133	−
Economic	Land-based production	Rice + wheat yield	tons/ha	12.9	+
	Economic production	Net income	yuan/ha	8939	+
	Industry & services	Input costs	yuan/ha	16916	+
Social	Provision of livelihood	Labour use	days/ha	263	−
	Human health	Biocide index	-	641	−
	Food security	Rice yield	tons/ha	7.3	+
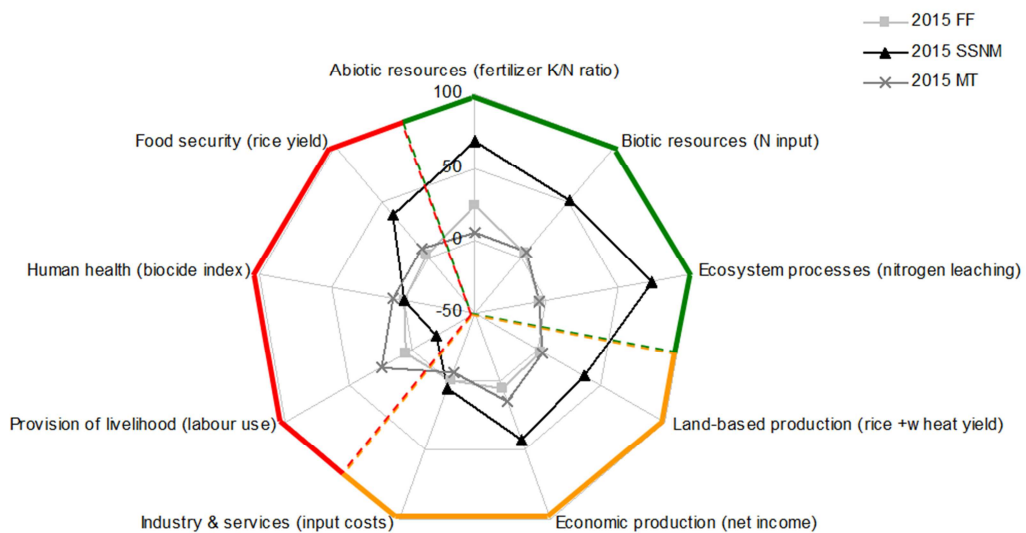
Figure 6.7. Modelling results for 9 indicators linked to Land Use Functions forecasting baseline changes towards 2015 for a conventional rice–wheat rotation on clay at field level using TechnoGIN (2015 BASE), and % change relative to 2015 BASE for a continuation of the current policy stimulating the use of formula fertilizer (2015 FF), the potential of a policy improving training and education on site-specific nutrient management (2015 SSNM), and a policy completely subsidizing machinery for mechanical transplanting of rice (2015 MT). The +/− indicates whether an increase was considered positive or negative; accordingly an increase in the area of the spider diagram indicates a positive influence on SD. To show the different impacts on environmental (green), economic (yellow) and social (red) LUFs, these are distinguished by colour. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

6.5.2 Documentation and communication

In communication with policy makers and other stakeholders, clear visualization and documentation of results as well as scenarios and associated assumptions are of major importance. Different ways of visualization are presented in this paper. A dataportal is used within the project to systematize and compare results across seven country-specific applications (http://lupis.cirad.fr/). Policy briefs have been distributed to disseminate the objectives and results of the project, during the national and the international policy forums, to the EC commission, and on other occasions. Stakeholders expressed interest in 'their own case', but also in the other cases within the same continent. Some country teams translated the briefs to national languages to promote reading for a larger group of people. The briefs were an important means to share information of problems and issues in a broad range of cases in Africa, Latin America and Asia along with the LUPIS framework for ex-ante impact analysis of land use policies. Furthermore, national policy fora and stakeholder workshops have been specifically useful in discussing the steps throughout the process, and will continue to be important to present results and to have impact in the policy arena.

6.6 Discussion and conclusion

In Europe, ex-ante IA studies boosted the scientific literature in recent years (e.g., Helming et al. 2008; Thiel 2009; Tscherning et al. 2008; Van Ittersum et al. 2008), due to the introduction of the Impact Assessment (IA) Guidelines in the European Union (Commission of the European Communities (CEC) 2009). Besides other objectives, these were introduced in order to make policy development more transparent and improve the quality of European policies (Bäcklund 2009). In developing countries such incentives from policy makers are few, and hence impact assessments of policies are usually of ex-post nature (e.g., Fan et al. 2008). Ex-ante assessments in developing countries generally explore potential technological or policy options instead of forecasting the impacts of more immediate and feasible options (e.g., Tittonell et al. 2009; Van den Berg et al. 2007; Van Ittersum et al. 1998). The projections in this study had a short time horizon (2015) due to its relevance to the 5-year planning strategy adopted in China.

The roles of models in societal problem solving can be (i) heuristic, improving understanding; (ii) symbolic, putting an issue on the political agenda; and (iii) relational, creating a community (Sterk et al. 2009). Although the impact of models has been less

than aimed for in many cases, positive effects on social learning, such as adapted problem definitions, direction setting, representation and management of boundaries and negotiation strategies, have been shown (Bouma et al. 2007; Pahl-Wostl et al. 2007). Involving policy makers and stakeholders throughout the modelling process is important to contextualize the modeling work, to create confidence in the work and to increase changes for the actual use of results (Sterk et al. 2011). In the LUPIS methodological framework the pre-modelling phase and the involvement of stakeholders have therefore received much attention.

Policies that are currently in place and relevant to the problem have been extensively evaluated (Bonin et al. 2009). In the Chinese case study, before the first national policy forum and the evaluation of policies, stimulating organic farming and green manure application were seen as attractive policy options, assuming that they reduce water pollution and other environmental impacts. It appeared however that due to the low fertilizer prices and off-farm employment, few farms cultivate organically and they are not interested in converting in the near future. Ex-ante impact assessment was therefore shifted to options that are considered feasible in the near future.

Interaction with stakeholders in the modelling phase for the Chinese case was mainly related to consultation on inputs and outputs of the models, including parameters, constraints and objectives. In many developing countries, data are lacking to parameterize process-based models. In several case studies of the project, we therefore applied the Framework for Participatory Impact Assessment (FoPIA; Morris et al. 2008), among which Indonesia (König et al. 2010), in which the whole methodological framework is followed and a qualitative impact assessment is done based on the expert knowledge of stakeholders. FoPIA does not substitute a quantitative analysis, but it provides a good starting point to guide for the most intriguing sustainability problems and can be used as a qualitative impact assessment tool where quantitative approaches and models fail (e.g., in the case of poor data availability, cross-disciplinary knowledge integration, stakeholder participation). Exercises in LUPIS using multi-criteria analysis to assess the impact of climate change on sustainable development in the case studies in Mali and Brazil (Verburg et al. 2009) also show that qualitative approaches can improve understanding among scientists and stakeholders. The use of LUFs in sustainable development evaluation helps to understand the importance of land use for sustainable development and to stimulate discussions among stakeholders. Methods have been developed to

aggregate multiple indicators into LUFs (Paracchini et al. 2011), but as this can be complex and less transparent, in this paper we chose to select one indicator per LUF. Although these indicators may not completely represent the full sustainability picture, understanding and comparing 9 indicators is already much, both for decision-makers and other stakeholders, and for researchers. When well selected, 9 indicators should be sufficient.

The assessment of policy options regarding site-specific nutrient management, mechanical transplanting for rice and buffer zones, show that it is feasible to simultaneously increase food production, increase net income and reduce impacts on the environment; main indicators related to the Millennium Development Goals and to Chinese policy documents. The methodological framework has proven useful in structuring and performing a sustainability impact assessment of land use policies (Mc Neill et al. 2012). It has been applied in six other LUPIS case studies with different land use problems, SD targets and modelling tools. Although the case studies diverge enormously in nature of local issues that are studied (e.g., agrarian crisis leading to suicides in India, land degradation and poverty in arid regions in Tunisia; www.lupis.eu), the flexibility of the framework has allowed applying it for different situations and its generic feature facilitates comparisons between case studies.

Chapter 7

General discussion and conclusions

7.1 Implementation of FoPIA to developing countries

For the implementation of FoPIA to the case studies in this study, existing components of the original FoPIA method as described in Morris et al. (2011) were complemented and further developed by integrating new structural elements following the LUPIS integrated assessment framework (see Chapter 6, Figure 6.1). Originally, FoPIA was developed based on the 'Driver-Pressure-State-Impact-Response' (DPSIR) model from Smeets and Weterings (1999) and considered the assessment steps of the scenario definition (selection of policy instruments, assuming that they will be fully implemented; D-P); the analysis of sustainability criteria and indicator selection (S); the impact assessment, including the analysis of sustainability limits; and the scenario preferences of stakeholders (S-I) (see Morris et al. 2011).

7.1.1 FoPIA adaptation process

The first objective of adapting the FoPIA method to the conditions of developing countries was addressed in the impact assessment conducted in Yogyakarta (Indonesia) and the Oum Zessar watershed (Tunisia). For this purpose, the original framework was divided into three manageable steps: (i) scenario development, (ii) specification of the sustainability context, and (iii) scenario impact assessment (see Chapter 2). Additionally, a new methodology for the communication of regional land use scenarios to local stakeholders and experts was integrated into the adapted framework (see Chapters 2 and 3). The elaboration of scenarios is a necessary prerequisite for a region-specific adaption but was widely predefined by policy proposals in the original FoPIA of Morris et al. (2011). Furthermore, additional emphasis was put on identifying possible recommendations for improved land use strategies as a final assessment step.

The second objective of using the FoPIA for a comprehensive impact assessment was realised in the case study of Guyuan in China where the large scale afforestation programme (SLCP) was assessed. For this purpose, two complementary FoPIA impact assessments were conducted; one assessment focused on the regional implementation of the SLCP (mainly using regional stakeholder knowledge), and the other one focused on alternative forest management options (mainly using scientific expert knowledge). The results of the two assessments were analysed by comparing key findings against other studies published in the scientific literature (Chapter 4).

The third objective of evaluating the suitability of the FoPIA for impact assessment in developing countries was addressed in Chapter 5. Based on the findings from five case studies, FoPIA was found to be particularly suitable for structuring the impact assessment, facilitating the involvement of stakeholders and experts and handling cross-disciplinary knowledge integration. In addition, FoPIA was also capable of being implemented in a varied context of different land use problems. Furthermore, another advantage of FoPIA is that it provides quickly obtained and transparent results and helps to identify possible sustainability trade-offs, which in turn can be used to identify sustainable land use strategies.

As mentioned above, the integrated framework presented in Chapter 6 provides useful assessment elements for adapting FoPIA to the conditions in developing countries and promotes FoPIA as a suitable assessment tool where data-driven computer-based tools fail.

7.1.2 Land use functions and indicators

As for the impact assessment, the LUF concept was at the core of FoPIA. The set of nine LUFs proposed by Pérez-Soba et al. (2008) was retained in all applications; however, the social LUF 'food security' was newly introduced (replacing the LUF 'cultural heritage' in all case studies except for the Oum Zessar watershed) to address this particular sustainability concern that is considered to be relevant in most case studies. The LUF 'human health' was replaced by the LUF 'quality of life' to consider the regional factors affecting rural life in general, including human health issues but also income availability, that could improve the living standards of rural people above subsistence levels. For the purpose of this study, the LUFs concept is generic enough to allow for a flexible adaptation to different regional contexts by adapting the regional definition of the LUFs; moreover, a balanced assignment of assessment indicators along the economic, social and environmental sustainability dimensions can be assured.

For the selection and acceptance of indicators, most stakeholders who participated during the various FoPIA workshops had a strong environmental background. Therefore, it is not surprising that the most accepted indicators were those covering environmental issues, such as the degree of soil erosion, the status of habitats and biodiversity, or the status of undisturbed and natural land. Economic indicators were usually also widely accepted, covering, for example, aspects of economic land-based production (e.g., yield), road

network and quality, off-farm income or built-up activities. The acceptance of social indicators was sometimes subject to debate, particularly those indicators that were not easy to capture, such as cultural identity or health issues. The qualitative nature of some social indicators, in general, makes social indicators more difficult to capture (Slee 2007). Overall, four criteria were defined to guide the selection of indicators, considering that (i) the indicator should be relevant to the region and the corresponding LUF, (ii) the indicator should be clear and understandable to all stakeholders, (iii) the indicator should be as precise as possible and measurable, and (iv) the indicator should not be redundant, i.e., not covered by another indicator. However, a distinction between the indicators of the economic and the social dimensions appeared to be unclear in some cases; for example, some stakeholders had different opinions about the indicator 'income' and whether this indicator should be included in the economic or social dimension. This example showed that the economic and the social dimensions are sometimes closely interrelated and may also be overrepresented if compared with the environmental dimension.

Although the 'nine-indicator solution' (one indicator per LUF) was sometimes criticised (particularly by the scientists involved) as too narrow to capture sustainability, the main challenge was handling the complexity arising from the indicator set to keep the assessment operational. Paracchini et al. (2011) proposed an aggregation framework to integrate multiple indicators per LUF, but this framework has not been empirically tested and was intended for situations in which the indicator values can be derived from other sources, for example, quantitative databases and models, whereas the aggregation of the individual indicators is desktop work. The experiences in this study indicate that only a few indicators are manageable within a participatory process. Using nine indicators on a workshop level, however, appeared to be a complex and challenging task, particularly when dealing with interdisciplinary stakeholder and expert groups amongst which all indicators needed to be understood, the impacts of all scenarios on each indicator needed to be assessed and the arguments associated with each indicator collected. By contrast, multiple indicators per LUF ultimately imply that indicators are different and have to be aggregated into a composite indicator to arrive at a clear result for each LUF, which would clearly reduce the transparency of the FoPIA results, a characteristic that was generally very appreciated by the stakeholders.

7.1.3 Stakeholder participation and expert knowledge

Stakeholder participation and expert knowledge are both crucial when conducting impact assessments of land use scenarios in the context of sustainability. It is important to reiterate that stakeholders are defined in this study as those organisations and individuals who are either directly affected by policy decisions (e.g., farmers, other land users) or are responsible for policy design or implementation (e.g., planners, decision makers). In contrast, an expert could be any person (e.g., a local farmer or an external expert) who is knowledgeable about the regional situation and contributes his or her knowledge to the assessment. The stakeholders' preferences are particularly required, for example, when defining regional sustainability targets, thus reflecting societal norms (see O'Farrell and Anderson 2010; Rametsteiner et al. 2011; Wiek and Binder 2005). Whereas expert knowledge is essential, for example, to define complex human-nature relationships of land use systems (see Burgi et al. 2004; Rounsevell et al. 2012; Verburg et al. 2002) or when dealing with the integration of interdisciplinary knowledge in impact assessment (see De Ridder et al. 2007; Gibson 2006; Marjolein and Rijkens-Klomp 2002; Ridder and Pahl-Wostl 2005). In this regard, Rounsevell et al. (2012) usefully proposed that it is crucial in trade-off analyses that science-based quantifications and value-based assessments both be used to consider the subjective choices and knowledge of stakeholders.

7.2 General findings from the case studies

Agriculture was the main land use sector in all of the regions in this study. In the districts of Guyuan (China), Bijapur (India) and Narok (Kenya), subsistence agriculture was widespread. In the Oum Zessar watershed (Tunisia), export-oriented agriculture was common, and many farmers produced cash crops. In the Yogyakarta region (Indonesia), which is a rural-urban region currently under transition, the agricultural sector contributed to the national rice supply during the past but is now declining as a result of urban development. The regional problems in all of the case studies were related to land use, resulting from the driving forces of population growth and economic development and the fact that land and natural resources are limited. The regional policies that were assessed addressed different objectives, focusing on environmental protection and food security in the Yogyakarta region, improved environmental conditions for land-based production in the Oum Zessar watershed, environmental restoration and poverty reduction in the Guyuan district, low-input farming practices to loose market dependencies of small-scale

farmers in the Bijapur region, and land use conflicts in the Narok district (see Chapter 5, Figures 5.1 and 5.4). Trade-offs among economic, social and environmental concerns usually depended on the policy objectives and regional preferences of the stakeholders and could not be generalised. Therefore, no clear win-win scenario among sustainability issues could be identified in most cases. However, in addition to highlighting regional sustainability trade-offs, this study found one common observation among all regions was that economic development conflicts primarily with environmental functions and services (e.g., in the case studies of Yogyakarta, Guyuan, and Narok) but can also affect specific social concerns (e.g., where small-scale or traditional famers are marginalised, as in the cases of Bijapur or Oum Zessar).

An analysis of the regional preferences for land use functions reflected major local sustainability issues. For example, with regard to economic functions, land-based production, mainly agriculture, was perceived by stakeholders to be of high importance in the predominantly rural regions of Guyuan, Bijapur, Narok and the Oum Zessar, whereas non-land-based activities, i.e., industry and services, were perceived by stakeholders to be of major importance in the rural-urban area of Yogyakarta, reflecting the main economic land use activities. The perceived importance of social land use functions varied amongst regions, highlighting the major local concerns, such as food security concerns in Yogyakarta and Guyuan (reflecting concerns related to declines in crop land and local food availability) and in Narok (reflecting concerns of increasing land degradation problems causing land to be unsuitable for production), quality of life in Bijapur (reflecting major problems of social distress and increasing farmer suicides), and the provision of work in Oum Zessar watershed (reflecting the challenge of living and working in water-limited areas). Environmental LUFs usually reflected major regional problems such as a lack of clean water resources, as in the case of Yogyakarta; water availability in the drought-prone watershed of Oum Zessar watershed; declining biodiversity in Guyuan; soil health problems related to the use of pesticides in the district of Bijapur; and threatened wildlife habitats in Narok.

7.3 Reliability of results

The results of FoPIA, when implemented as a stand-alone approach without extensive additional data sources such as monitoring data or quantitative models, are based on the qualitative knowledge of stakeholders and experts and thus, to a large extent, subjective opinions. The consideration of subjective and qualitative information is sometimes

criticised to be a shortcoming in the quality of the impact assessment results (Wilkins 2003). For example, in cases where "less confident" stakeholders were involved, whether they shared their "true" opinion or whether the entire impact assessment set up (e.g., the presence of foreigners, venue, understanding of concepts, etc.) had an intimidating effect on them remained unclear. Situations of possible biases were given in some cases, for example, by hidden hierarchical structures (Yogyakarta, Indonesia) or politicised policy scenarios (Guyuan, China). The need to consider qualitative stakeholder and expert knowledge as a source of information in impact assessments when addressing sustainable land use is crucial, and the inherent subjectivity can be reduced by emphasising a careful and balanced selection of the stakeholders and experts contributing to the assessment. To support the qualitative assessment results, the results of the FoPIA workshops were analysed by comparing them with the available scientific literature before formulating recommendations for improved land use strategies. In some cases, the scientific literature for specific regions was limited (e.g., Yogyakarta, Indonesia), reflecting the more general problem of limited data availability in developing countries, and required a broader survey of the literature that included, studies from outside the study regions.

The quality of the FoPIA results is also influenced by scenario assumptions (e.g., level of detail, time horizon, quantification of land use changes, contrasting scenarios), the indicators selected, and the availability of secondary (hard) data used to complement the assessment. Attributing changes in ex-ante impact assessments is one of the biggest challenges and can be a difficult task when dealing with both direct and indirect, intended and unintended effects (Baur et al. 2003; George and Kirkpatrick 2006; Thornton et al. 2003). While being aware of possible methodological shortcomings of the FoPIA method, I tried to optimise the quality of the FoPIA results by putting forward a critical reflection of the impact assessment results, communicating and considering feedback of the assessment findings on the local level and complementary use of science-based evidence.

7.4 Perspectives

7.4.1 Delphi-approach

During the course of the FoPIA applications for this thesis, several adaptations were made based on experiences gained from the five regions. However, the overall set up with regard to scenario development, indicator selection and impact assessment was kept the same in all regions to allow for comparability among case studies. For future applications,

it could be tested how far the steps conducted during the workshop could be shifted to the preparation phase of FoPIA to reserve more time for the most important step of the workshop (the impact assessment) and to limit the level of fatigue among the group panel after completing the previous FoPIA steps. For example, it is conceivable to better inform the group prior to the workshop by sending them detailed background information on the outline of the workshop and the utilised scenarios as well as draft indicators. This procedure may be realised in English-speaking case studies (e.g., Narok) but also depends on the target group and sometimes limited internet access in remote rural regions (e.g., Guyuan and Bijapur). It could also be tested whether the land use functions and indicators could be developed before the workshops, for example, with a survey (e.g., web- or paper-based) following a Delphi-approach. The Delphi-approach usually includes two or more expert rounds. After each round, the experts are given summarised information of the results from the previous round (e.g., the indicators proposed by the group as well as arguments given for the assessment[13]) and can adjust their indicators or scores after reflection of the group result. This method can reduce the range of opinions and also leaves more time for this important step compared with the time constraints at the workshop (at the desk, the experts have more time to think and perhaps to consider additional literature and material). However, this potential step implies that experts have to be identified with enough time prior to the workshop; the requested task may interfere with other project deadlines or other appointments, and the experts need to be motivated enough to participate in such a long process. Experiences from other studies show that a considerable number of experts usually resign from a Delphi-process; particularly, if more than two rounds are planned. In addition, significantly more resources for the translation of materials into local languages have to be considered, which could be a possible obstacle to a Delphi-approach, although in countries where English and French are frequently used (at least among experts), this Delphi-approach could be feasible.

7.4.2 Institutional context

One crucial aspect when addressing land use policies is the context of the institutions. Many developing countries face the challenge of weak institutions as well as occasional corruption, which often lead to ineffective law enforcement or only partial implementation of policy instruments (Mc Neill et al. 2012). The understanding of

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[13] For an example, see Marggraf (2003), who conducted a paper-based Delphi-study to assess agri-environmental programs in Germany

institutional mechanisms appeared to be of particular interest in case study regions where stakeholders were interested in knowing whether the "best" scenario option could potentially be realised or not (for example, in the case of the ecotourism scenario in Narok, Kenya). This aspect was partly considered in the integrated framework, as described in Chapter 6, and could be adapted for the future application of FoPIA. In the integrated assessment framework (Chapter 6), the indicator framework was extended by including three additional (non-LUF) institutional indicators. These indicators included *legal enforcement*, *farmers' associations* (public awareness and participation), and the *economic importance of the agricultural sector*. The FoPIA method in its current version does not explicitly account for institutional aspects but could be further complemented and improved, for example, by integrating a check list of institutional indicators in the scenario development step and addressing the likelihood that a specific scenario (land use option) can be implemented.

7.5 Conclusions

An impact assessment of land use scenarios can enhance the understanding of complex human-environmental systems and has the potential to promote sustainable development. This study demonstrated the use of the FoPIA method, which was originally developed in the European context, for conducting impact assessment of land use scenarios in developing countries. The advantage of using the FoPIA approach is its formalised but flexible and transparent structure, which can be used to facilitate a regional discourse promoting sustainable development. FoPIA supports the identification of the causal relationships underlying regional land use problems and can be used to illustrate the effects of alternative decision options on the economic, social and environmental dimensions of sustainability. For this study, the FoPIA method was effectively divided into three manageable assessment steps: (i) scenario development, (ii) specification of the sustainability context, and (iii) scenario impact assessment. For the assessment of land use scenarios, expert knowledge is essential to defining human-environmental relationships, and stakeholder participation is crucial to considering local preferences and implicit knowledge regarding regional land use.

The results of the various impact assessments presenting in this study showed that there will be no clear win-win situation between the economic, social and environmental sustainability dimensions. In most cases, the assessed land use policies followed one or two specific goals, aiming, for example, at preserving the environment, improving

economic production, or promoting social measures. Depending on the regional context and the stakeholders' preferences, it is likely that policy-induced land use changes will always produce sustainability trade-offs that can be minimised once they are identified. Therefore, a sustainability impact assessment using FoPIA, if well prepared and including a carefully selected stakeholder or expert panel, has a high potential to raise awareness regarding possible sustainability trade-offs, which in turn could be used by responsible decision makers to implement sustainability-oriented land use strategies.

Based on the five case study applications in China, India, Indonesia, Kenya, and Tunisia, FoPIA was demonstrated to be a suitable impact assessment tool for application in developing countries and proved to be appropriate as an initial assessment tool. However, FoPIA should, whenever possible, be accompanied by evidence from monitoring data or analytical assessments. When using FoPIA for a policy oriented impact assessment, it is recommended that the process should follow an integrated, complementary approach that combines quantitative models, scenario techniques, and participatory methods.

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Note: König, H. and König, H.J. refer to the same author in this study

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Declaration

I prepared this dissertation without illegal assistance. The work is original except where indicated by special reference in the text, and no part of the dissertation has been submitted for any other degree.

The five main chapters (Chapters 2 to 6), which have been considered for publication in international, peer-reviewed journals, were all co-authored. I am the first author of the papers in Chapters 2 to 5 and second author of the paper in Chapter 6. My contributions to the chapters are highlighted in the introductory section or noted in the text.

Erklärung

Die geltende Promotionsordnung der Mathematisch-Naturwissenschaftlichen Fakultät der Universität Potsdam ist mir bekannt.

Die vorliegende Dissertation habe ich selbständig angefertigt und hierbei alle verwendeten Hilfsmittel und Quellen angegeben.

Ich habe weder die vorliegende Arbeit noch eine in wesentlichen Teilen ähnliche Abhandlung bei einer anderen Hochschule als Dissertation eingereicht.

Potsdam, den 04. September 2012

Hannes J. König