Linking processes and pattern of land use change

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General discussion and conclusions

7.1 Land use in San Mariano

This dissertation has a strong methodological focus. Nevertheless, some substantive con
clusions for the local case in San Mariano can be drawn from the analyses. The analyses
the explanatory factors of land use change (Chapters 2, 3 and 4) revealed the main proce
that determine the distribution of various land use types in the area. These explanatory
tors can be categorised in three groups: accessibility, origin of the people and biophysica
constraints.

For cash crops, for example yellow corn and banana, accessibility to the market is an im
tant factor because it determines the transportation costs. Furthermore, lack of accessibil
in the wet season can impose restrictions to the cultivation of cash crops. During the we
season transportation is diffi cult or even impossible and storage of the yield is oft en nc
an option because appropriate storage facilities are lacking. The distance between the fi
and the place of residence is also an important determinant of crop choice because peop
prefer to live close to their fi elds (Verbur *et al*. 2004a). Improvements of accessibility anc
reduction of transportation costs can improve the livelihood of people in the area becau
it would increase profi tability of the crops they produce. However, bett er accessibility
increases the access to the forest for illegal logging activities. Improved accessibility will
also att ract more people, because locations further from the market become accessible t
start a farm.

Other important determinants of what crops people cultivate are ethnicity and migratio
background. Based on preferences and habits some ethnic groups prefer to produce cor
and other prefer to produce rice. Generally speaking, migrants, defi ned as people born
outside the municipality, are more involved in growing rice and less in growing corn th
people that were born in San Mariano. This relation is partly caused by the fact that mi-
grants sett le in places far away form the market town where growing corn is less profi t
Another reason is that the people that currently migrate to the area are of diff erent ethn
background than the people that have a longer history in the area. These new migrants
oft en prefer to cultivate rice rather than corn. A third reason is that the migrants oft en
not have capital to invest in inputs for cash crops and therefore start with rice productio
to be self-suffi cient for their famili

For agricultural production the fl at and rolling areas are the most suitable. Especially ar
crops are preferably cultivated on the fl at parts. Perennial crops, for example banana, ar
also cultivated in the rolling parts. For the production of irrigated rice an extra requirem
is that it needs a source of water. This can be a creek or an irrigation facili
If one compares the allocation of the two most important cash crops in the area, which a
corn and banana, in relation to their profi tability alone it seems that a relatively larger a
is planted with corn than would be expected (Verbur *et al.*, 2004a). This has two reasons
One reason is that approximately once in fi ve years the area is hit by a large typhoon. T
damage of these typhoons is such that the bananas will not bear fruits for a year. If this
damage is taken into account the calculated yearly profi ts from banana are actually low
Another important reason is that corn production in the area is most oft en fi nanced wi
credits from traders that provide the seeds and agrochemical inputs. On the one hand
many farmers are actually happy to have access to a source of money and use the credit
also for consumptive use. On the other hand to farmers are oft en indebted for a longer t
and therefore forced to grow corn (Van den Top, 1998). Therefore, more corn is grown in
the area than could be expected from a narrow, purely economic point of vie
From scenario analysis in Chapter 6 the following can be concluded. The forested area in
the northeastern part of the study area, which is part of the natural park, is most under
threat under a high growth scenario without forest protection. Most of the remaining fo
est, however, has a kind of natural defence, because the slopes are steep and not suitable
for arable production. The scenario study shows that it is possible to increase agricultura
production by making use of the grasslands in the hilly part, where land is still avail-
able. In that case the forested parts may be spared. A negative scenario, which already
can be observed in other parts of the Philippines, is that all forested areas will eventually
be cleared for agriculture. However, taking these areas into production oft en provides
only temporary solutions for the smallholders because without appropriate conservation
measures the soils in the mountainous areas are prone to erosion, which eventually will
lead to less productivity
The key to a sustainable future in San Mariano, apart from larger economic and political
developments in the region, is migration control and a strict implementation of environ-
mental legislation and land use policies. As can be seen from scenario analyses (Chapter
the area that is already cleared from forest and which is currently under grass can be use
to facilitate a large part of the increase in agricultural production. To create viable oppor
nities to cultivate on these marginal grassland the people should be assisted to impleme
sustainable agricultural practices. Even more important, these measures should go hand
in hand with regulations to prevent the agricultural area from expanding into areas that
are currently under forest. For example, improvements of the accessibility of the area wi
increase the opportunities to make a living for the current population, but will also att ra
people that will enter the marginal areas that have become more accessible. Therefore,
improvements in accessibility should come with regulations to prevent extension of the
cleared area and creation of new sett lements. A constraint in taking the grasslands into
production is that most of these areas are claimed by local farmers. This factor was not
included in the model and may actually prevent these areas from being taken into produ
tion by others than the owners. Therefore, most of the immigrants currently open up the
own areas to claim land. To enable immigrants to make use of the grasslands the land ha
to be made available to them at low cost. An alternative is to stop immigration and the
creation of new sett lements. In that case it is to be expected that agricultural expansion

will mainly take place in the grassy areas because these areas are owned by the families that live there and no new land has to be cleared. The municipality of San Mariano coul benefi t from clear decisions on land use planning by assigning some areas to agricultur and investing in these areas to enable people to make a good living, and assigning other areas for the conservation of the sparse forested areas left . However, this approach also requires means to invest in sustainable agriculture as well as implementation of the law and policies that offi cially are already operati

7.2 Methodologies for land use science

In this section general conclusions are presented regarding methodology for land use sc ence. Diff erences between land use analyses in the same area by using diff erent discipl approaches (Chapter 2) stem from diff erences in unit of analysis, diff erences in sample design, diff erences in the themes included and diff erences in the methods that were us to collect the data. Analyses from a specifi c disciplinary perspective can help to underst part of the land use system, but cannot explain the complete system. Therefore, proposi- tions should be stated carefully and clearly and should provide explicit information abo the unit of analysis, the sample design and the included variables. In Chapter 2 the fi elc included in the household analysis to have a similar unit of analysis as the geographical approach. Thematically, the variables included in both models are the same. Neverthele the results are diff erent due to diff erences in sample design and data collecti

Land use research covers a range of approaches between inductive and deductive. Indu tive, oft en statistical, approaches can provide correlations between land use and explan tory factors. These statistical analyses can be used to fi t the data as well as possible. Dec tive theoretical frameworks can specify relations between explanatory variables and the subject to be explained in a fl exible way and are capable of representing causal relations By validating theoretical frameworks (Chapter 3) the full causal structure is tested, whic leads to a bett er understanding of causality and supports theory buildir

Multilevel analysis (Chapter 4) is a valuable tool in land use research to unify diff erent scales and levels in one statistical analysis. Disciplinary approaches oft en have diff eren units of analysis, which hampers the comparison or combination of various methods. Be cause multilevel analysis allows the incorporation of variables at diff erent levels, diff er units of analysis can be combined. Aggregating or disaggregating variables to the unit of analysis, which has statistical disadvantages, is therefore not necessary. This method allows a multitude of propositions between higher and lower levels to be made and test of the relations between levels and scales. The case study revealed the importance of the household level in explaining land use at a detailed level in the study area. Generalising this, it can be concluded that all organisational levels between the resolution and the ext should be examined for their importance in explaining land us

A wide category of land use studies apply an inductive patt ern-based method to identif drivers of land use and, subsequently, to use these drivers in spatially explicit land use models. As such this is a valid method, though the approach brings about a number of restrictions. Inductive approaches are weak in the description of causality and processes This restricts models that are based on an inductive analysis for modelling large change in processes, for example the introduction of a new land use type. An alternative is to us a theoretical, process-based approach, for example an actor-decision framework (Chapte

5), to derive and describe relations between land use and its explanatory factors. If such an approach is used the models can be made more fl exible regarding the introduction o new land use types and changes in processes during the modelling period. This approac is most valuable in small study areas where detailed actor research can be carried out ar can be used for detailed policy analysis. Large-scale studies can best be carried out with inductive approach, for example based on statistical analysis relating land use patt erns number of explanatory variables available in maps. Their use is more in modelling gene trends, for example in the identifi cation of hotspots of land use change. The two diff ere approaches to specify spatially explicit land use models each have their consequences fc use in policy-making. The choice of one approach or the other depends on (1) the resear question and the policy context of the study (Chapter 5) and (2) the wider use of the stu in scientifi c programmes and theory building (Chapter 3

In order to use land use models in policy-making eff ectively the projections of future la use patt erns should be translated into normative indicators that describe consequences biodiversity, agricultural production and watershed properties, for example. To do this additional studies have to be carried out that link land use changes to their eff ects. The patt ern of the eff ects of land use changes may be diff erent than the locations where the land use changes occur for two reasons. Land use changes may have off -site eff ects, wh implies that land use changes at a certain location has an impact on other locations than itself, for example downstream. Secondly, land use changes may have diff erent eff ects in diff erent locations. For example, a land use change in a location with a low value for biodiversity has less impact for biodiversity conservation that the same land use change a locations with a high conservation value. In general, the locations of land use change c not necessarily have to be the same locations as where the eff ects take place. Moreover, eff ects of land use changes may in themselves infl uence land use decisions. Therefore i important to assess the eff ects of land use changes and incorporate feedbacks of land us change into land use studies

7.3 Value of the combination of approaches in the presented study

In this thesis it is the combination of approaches that have led to a greater understandin the land use system in the study area. A summary of the key methodological componen is in Figure 7.1. The empirical data can be categorised in three parts: Qualitative data fro unstructured interviews, quantitative data from a household survey and a spatial datase The approaches for the collection of these three datasets have their origin in diff erent re search paradigms and cover the fi elds of qualitative gamma sciences, quantitative gam sciences and geography respectively. Furthermore, the horizontal dashed lines (Figure 7 indicate the three research categories indicated in Chapter 1: Observation and monitorir of land use change (top), identifi cation of the drivers of land use change (middle) and dynamic modelling of land use change (bott om

The fi rst analyses were carried out in a rather disciplinary way, but aimed at facilitating comparison and exchange of information. The study started with a statistical analysis of the household data (Chapter 2). By using the fi eld as the unit of analysis this household analysis could be used to inform the statistical analysis of the spatial data by including the themes that were important explanatory factors at the household level. The househo analysis was also used to inform the descriptive Action-in-Context (AiC) analysis (Chap

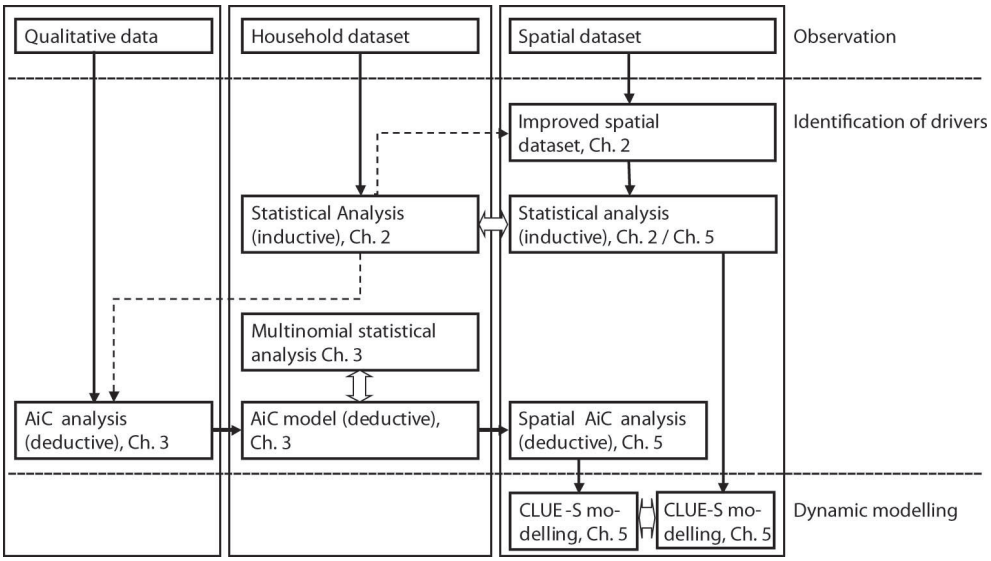

Figure 7.1: Sequence of methodological approaches throughout the present study. Solid arrows indicate direct links, dashed arrows show informing links and the wide arrows indicate comparisons

3), which was mainly based on the qualitative information. Subsequently, the AiC analy was used to construct an actor decision model (AiC model) that was validated with the household data. Finally, the AiC analysis was translated to a spatial approach and used parameterise the CLUE-S land use model (Chapter 5). In this way the AiC analysis serve as a cross-level and interdisciplinary approach. (Chapter 4 (multilevel analysis) is not included in Figure 7.1)

Many land change scientist seek the development of theories of land use change. As dis· cussed in Chapter 3, moving up and down between empirical, inductive methods and theoretical, deductive methods as described above is a useful approach to stimulate thec development. Relations derived in inductive approaches can be used to structure the pr cess of theory building. Subsequently, theoretical causal structures can be developed an tested. From there, one can move a step back in the direction of induction by calibrating the theoretical model with empirical data to get a bett er model fi t. This process could g through several steps moving up and down between inductive and deductive approach to improve the theories and the models to describe the land use processes. In this respec the study that forms this dissertation is an example of the approach described in Chapte 3.

With the presented combination of approaches it was possible to combine various disci- plinary aspects in the AiC model. Applying diff erent methods forces the research into a integrative approach. In this way we were able to construct an interdisciplinary AiC mo and to incorporate process information in the spatially explicit land use model. Without this mix of approaches the analyses would have been dominated by one disciplinary pa digm and a truly integrative approach of the various aspects of the land use system wou have been diffi cul

7.4 Lessons learned from performing interdisciplinary research

As argued before, land use is a fi eld of research that involves many disciplines. To com integrated land use studies it is inevitable to do multidisciplinary or interdisciplinary re search. Multidisciplinary research refers to a group eff ort in which a number of discipli are represented which exchange information, for example between disciplinary models. The important diff erence with interdisciplinary research is that in an interdisciplinary study new paradigms and methods are developed apart from the existing disciplinary a proaches and which have a position in between the contributing disciplines. This paragr reports on the experiences of working on an interdisciplinary study. In retrospect these experiences are largely the same as formulated by Pickett *et al*. (1999) and Schoenberger (2001), which demonstrates these experiences have a kind of universal valu

In itself, the present study aimed at integrating disciplines but the project was also carried out in a larger interdisciplinary program. Cooperating within a group with people from various backgrounds turned out to be crucial in carrying out truly interdisciplinary research. Generally speaking, people are educated in a disciplinary way, which will lead to a disciplinary bias in their thinking and their approach to handle a research question, whether consciously or unconsciously. Involvement of people from diff erent backgroun will automatically lead to diff erent perspectives. Thus, interdisciplinary research should a group process. A drawback of a group process is that it will cost more time than worki alone or in a disciplinary group. It takes time to understand each other to reach consens about the way to proceed

A number of issues can be identifi ed that can contribute to the interdisciplinary researcl process. First of all, it is important to have a common problem or research question. Loo formulated, in this project the common research question was: Why do people manage t land the way they do and why at that location? Secondly, it is important to have a numb of methods in common. In this project an actor decision-making framework was adopte that was used by two of the researchers. Picket *et al.* (1999) argue that both deductive anc inductive approaches should be part of interdisciplinary research. Mature specialities ha oft en well developed theories but less developed disciplines and interdisciplinary resea can oft en benefi t from inductive approaches. As was concluded in Chapter 3, inductive research can help to identify the factors that are important to land use and this informat can be used as a guide in constructing mechanistic and causal hypotheses. Thirdly, havi a research question and methods in common will help to develop a common vocabulary which is very important for clear communication and cooperation. Disciplinary researcl all have their own research culture, where the meaning of words and concepts are know but which cannot always easily be understood by others. A fourth help in interdisciplina research is to have a common research site and, if possible, to share dat

Interdisciplinary research involves incorporating contradictory and ill-fi tt ing elements. Unless an all-encompassing theory that includes all disciplines in a balanced manner is available, disciplines and disciplinary methods will compete for their position in a study Disciplinary 'truths' and certainties are questioned and may even be violated. The most general theories in each of the contributing disciplines are oft en too abstract to link witl other disciplines (Pickett *et al*., 1999). So, in interdisciplinary research it is necessary to scarify some of the disciplinary detail in order to establish links with other disciplin

7.5 Perspectives in land change science

The LUCC project (Turner *et al*., 1995; Lambin *et al*., 1999), which played an important part in the development of land use science, started in 1995 and ended in October 2005. The LUCC project is succeeded by a new initiative called the Global Land Project (GLP, 2005). This provides the opportunity for renewed agenda setting for land change science. Below some of the thematic and methodological issues that are currently identified for the research agenda are discussed.

Two examples of thematic topics that need the attention of the land science community are globalisation and vulnerability. The locations of production and locations of consumption are disconnected more and more *i.e.* globalisation) due to, amongst others, migration and urbanisation (Turner *et al*., 2004; LUCC scientific steering committee, 2005). Land change science has to include the links between local and global developments. A theoretical example that rewrites Von Thünen's theory in this respect by disconnecting the locations of production and consumption is in Walker and Solecki (2004). In this thesis the case of corn production shows that even for a distant frontier system the influence of goods for a distant market is large. Growing urban populations in the Philippines increase the demand for feed-corn, which is produced in the uplands, through increased meat consumption (Coxhead and Buenavista, 2001). Currently, the corn market is protected in the Philippines (Coxhead, 2000). Liberalisation of this market, which is currently considered, can lead to large shifts in the crops produced because feed corn may be imported instead of produced in the Philippines.

Vulnerability of society and ecosystems is another issue that needs more attention (Turner *et al*., 2004). Land use research tended to focus on slow variables and underlying factors. However, land use systems are also to a large extent determined by extreme events (both human and biophysical). Extreme events determine the resilience and collapse of systems and thereby the system's vulnerability (LUCC scientific steering committee, 2005). In the study area droughts and typhoons have important direct effects for the population in the area, but also largely determine the functioning land use system as such (Huigen and Jetten, n.d.). Many of the land use decisions in the area cannot be explained without taking the extreme events into account. For example, for the case of banana Verburg *et al*. (2004a) found that based on accessibility banana would be more profitable than corn. However, most instances corn is preferred above banana. A part of the explanation for this paradox turned out to be that the area is regularly hit by typhoons, which destroy the bananas and therefore impede production for more than a year.

The LUCC science community has developed a wide range of tools and methods to use land use studies. Below we discuss some methodological issues that are currently advocated as being the way to proceed in land change science.

It is widely acknowledged that land use research is to be carried out in a comprehensive and integrated manner. Especially, integrated (computer) modelling by combining social and biophysical drivers, modelling of decision-making by agents, modelling of lag times, modelling thresholds, and multi-source data integration are promising methodologies (LUCC scientific steering committee, 2005). Under the umbrella of integrated approach a multitude of approaches can be identified.

Many scholars describe the land use system as a so-called coupled human-environment system (e.g. Turner *et al*., 2004) and a number suggest treating this system as a complex system and adopting complexity theory in studying the system. Although complexity theory

itself is an ill-defi ned term (Manson, 2001) it includes a number of phenomena that are characteristic for land use change processes and which are studied to some extent alread for example self-organisation, emergence, path dependence and feedbacks (O'Sullivan, 2004). These phenomena are part of what Manson and O'Sullivan call aggregate comple ity, which stems from a holistic and synergetic paradigm that deals with interactions of variety of system components. These features mean that complex systems have oft en ve diff erent characteristics than systems that are in equilibrium, which is a basic assumptic in many other economic and ecological theorie

Some scholars argue that 'land change science' is currently emerging as a new science (Turner *et al.*, 2004; Rindfuss *et al.*, 2004; Lambin *et al.*, 2005). Lambir *et al.* (2005) argue tha the time is ripe for an overarching theory: "Emerging sciences need their own theories". This call for an overarching theory is meant in a methodological sense rather than a call new substantive theories as the theories of Von Thünen, Malthus and Boserup (Von Thü 1966; Malthus, 1967; Boserup, 1965). This overarching theory should incorporate issues such as behaviour of people, feedbacks, multiple levels, time and links with the broader world (Lambin *et al.*, 2005). Although the authors also mention some of the diffi culties a say that land use science is not yet able to produce such a theory there are some additio reservations to this call for an overarching theory. Apart from the question of whether it is possible to create an overarching theory, such a description has the risk of becoming incredibly complex, because all land use scientist have their own list of topics, processes and mechanisms that they would like to include in such a theory and these lists will nev be the same for all scientists. Additionally, when such a large all-encompassing theory h to be implemented using computer models and practical tools one may be confronted w many diffi culties regarding verifi cation and validation of the system, data needs, comp ing capacity, etc. Furthermore, one all-encompassing theory may decrease the att ention search for alternative solutions. This may reduce the diversity of approaches in land use science, which is essential for integrative research as is concluded in this thes

In this thesis a framework for the analysis of environmental problems was adopted for the analysis of land use decisions. This so-called Action-in-Context framework (De Groo 1992) is a promising tool in solving a large part of the land use jigsaw puzzle. Especially by combining the actors fi eld (analysis of relation between primary, secondary, etc. actors) and the deeper analysis (in depth analysis of decisions of one actor or actor group), which was used in this thesis, the framework can incorporate a wide diversity of land u relevant issues. The deeper analysis was used throughout this study as a methodologica framework for land use decisions. Furthermore, the multilevel approach (Chapter 4) is a very promising statistical method to bridge scales and levels and therefore to integrate disciplines. Although these methods link various parts of the land use system they do n provide the overarching methodological theory that includes all elements of the land us system.

With the above considerations in mind we would like to argue that theories of land use methodologies should focus on the combination of parts of the complex system at a leve between disciplinary elements and an overarching theory. The combination of disciplina elements of the system can lead to understanding of more and more sub-systems, which eventually proceeds in the direction of a larger theory. An all-encompassing theory of la use change is still far off . Theorising on these subsystems may provide smaller steps tha contribute to the overarching theory and prevents a fi xation on a fi nal solution that wo

draw att ention away from alternatives that can provide important contributions. These theories of part of the system should aim at the true integration of some of the discipline and methodological themes and should describe actual mechanisms and processes. Lan use modelling has to focus on the development of mechanisms that enable integrative research rather that adding more elements to existing models. For example, integrating feedbacks, path dependency and emerging properties are not fully understood theoretically and neither is the potential of these issues suffi ciently explored with modelling ap proaches. For example, integrated systems that include projections of the amount of lan use change, allocation of land use, their eff ects and their feedbacks into the land claim a land use allocation are hardly (or not) availabl

On the part of the substantive theories land use research would benefi t from testing the theories in real world cases. In this thesis broad rational choice was tested by making th AiC framework operational in the study area, which proved to work well for the predic tion of the occurrence of land use

In this dissertation various methods were applied from diff erent disciplinary perspectiv Both deductive, theoretical as well as inductive, statistical approaches were used. The jo understanding from these analyses enabled the integration of all important aspects in or modelling framework. The modelling was an important tool to organise the knowledge available about the complex system and added to the insight in the system as a whole. The combination of methods has been the key to improved understanding of the land us system.