

# Linking processes and pattern of land use change Overmars, K.P.

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# 7

## **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 biophysical constraints.

For cash crops, for example yellow corn and banana, accessibility to the market is an impact tactor because it determines the transportation costs. Furthermore, lack of accessibility in the wet season can impose restrictions to the cultivation of cash crops. During the wet season transportation is difficult or even impossible and storage of the yield is oft en not an option because appropriate storage facilities are lacking. The distance between the firm and the place of residence is also an important determinant of crop choice because peop prefer to live close to their fields (Verbur *et al.* 2004a). Improvements of accessibility and reduction of transportation costs can improve the livelihood of people in the area because it would increase profit tability of the crops they produce. However, bett er accessibility of increases the access to the forest for illegal logging activities. Improved accessibility will also attract more people, because locations further from the market become accessible to start a farm.

Other important determinants of what crops people cultivate are ethnicity and migration background. Based on preferences and habits some ethnic groups prefer to produce comand other prefer to produce rice. Generally speaking, migrants, defined as people born outside the municipality, are more involved in growing rice and less in growing corn the people that were born in San Mariano. This relation is partly caused by the fact that migrants sett le in places far away form the market town where growing corn is less profit. Another reason is that the people that currently migrate to the area are of different 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 onthave capital to invest in inputs for cash crops and therefore start with rice production to be self-sufficient for their familie.

For agricultural production the fl at and rolling areas are the most suitable. Especially are crops are preferably cultivated on the fl at parts. Perennial crops, for example banana, are 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 profits from banana are actually low Another important reason is that corn production in the area is most oft en fi nanced will 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 for 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 available. 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 environmental 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 have 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 could benefit from clear decisions on land use planning by assigning some areas to agriculturand 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 laws and policies that officially are already operative.

## 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 specific disciplinary perspective can help to underst part of the land use system, but cannot explain the complete system. Therefore, propositions 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 field 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. Indutive, oft en statistical, approaches can provide correlations between land use and explantory factors. These statistical analyses can be used to fit the data as well as possible. Decitive 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, which leads to a bettier 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 use

A wide category of land use studies apply an inductive patt ern-based method to identificativers 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 changes 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 approach is most valuable in small study areas where detailed actor research can be carried out are 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 patterns number of explanatory variables available in maps. Their use is more in modelling gene trends, for example in the identification of hotspots of land use change. The two differer approaches to specify spatially explicit land use models each have their consequences for 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 study in scientific programmes and theory building (Chapter 5).

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, whimplies 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 on 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 use 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 understanding the land use system in the study area. A summary of the key methodological component is in Figure 7.1. The empirical data can be categorised in three parts: Qualitative data from 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 different research paradigms and cover the fields of qualitative gamma sciences, quantitative gamma 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), identification 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

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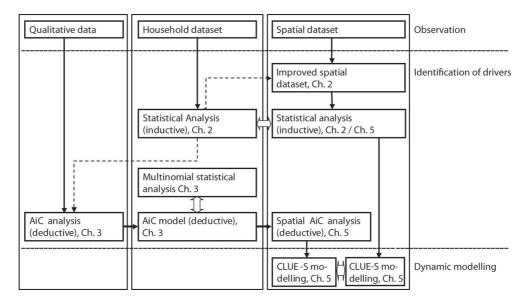


Figure 7.1: Sequence of methodological approaches throughout the present study. Solid arrows indicate direct links, dashed arrows show informing links and the wide arrows indicate comparisons

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 discussed in Chapter 3, moving up and down between empirical, inductive methods and theoretical, deductive methods as described above is a useful approach to stimulate theoretical, deductive methods as described above is a useful approach to stimulate theoretical cavelopment. Relations derived in inductive approaches can be used to structure the process of theory building. Subsequently, theoretical causal structures can be developed and 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 fit. 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 respect 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 disciplinary 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 paidigm and a truly integrative approach of the various aspects of the land use system wou have been difficul

### 7.4 Lessons learned from performing interdisciplinary research

As argued before, land use is a field of research that involves many disciplines. To come 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 disciplinary research. 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 leac 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 backgrour 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 work: alone or in a disciplinary group. It takes time to understand each other to reach consensi about the way to proceed

A number of issues can be identified that can contribute to the interdisciplinary research 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 adopted that was used by two of the researchers. Picket et al. (1999) argue that both deductive and inductive approaches should be part of interdisciplinary research. Mature specialities has oft en well developed theories but less developed disciplines and interdisciplinary resea can oft en benefit 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 research 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 interdiscipling 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 with 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 disciplina

## 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 scienc Below some of the thematic and methodological issues that are currently identified for tresearch agenda are discussed

Two examples of thematic topics that need the att ention of the land science community globalisation and vulnerability. The locations of production and locations of consumptic are disconnected more and more *i.e.* globalisation) due to, amongst others, migration an urbanisation (Turner *et al.*, 2004; LUCC scientific steering committ ee, 2005). Land chang science has to include the links between local and global developments. A theoretical ex ample 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 conjunction 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 Philippir (Coxhead, 2000). Liberalisation of this market, which is currently considered, can lead to large shift s in the crops produced because feed corn may be imported instead of producin the Philippines

Vulnerability of society and ecosystems is another issue that needs more att ention (Tur *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 (bot human and biophysical). Extreme events determine the resilience and collapse of system 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 Jen.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 parado turned out to be that the area is regularly hit by typhoons, which destroy the bananas ar 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 socia and biophysical drivers, modelling of decision-making by agents, modelling of lag times modelling thresholds, and multi-source data integration are promising methodologies (LUCC scientifi c steering committ ee, 2005). Under the umbrella of integrated approach multitude of approaches can be identifi e

Many scholars describe the land use system as a so-called coupled human-environment system (e.g. Turne *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 ved different characteristics than systems that are in equilibrium, which is a basic assumption many other economic and ecological theories

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 that 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 difficulties a say that land use science is not yet able to produce such a theory there are some addition 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 difficulties regarding verification 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 Groc 1992) is a promising tool in solving a large part of the land use jigsaw puzzle. Especially by combining the actors field (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 us 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 no 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 disciplinary 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 the contribute to the overarching theory and prevents a fi xation on a fi nal solution that wo

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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. Lanuse 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 sufficiently explored with modelling approaches. For example, integrated systems that include projections of the amount of lanuse change, allocation of land use, their effects and their feedbacks into the land claim a land use allocation are hardly (or not) available

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

In this dissertation various methods were applied from diff erent disciplinary perspective. Both deductive, theoretical as well as inductive, statistical approaches were used. The jounderstanding 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.