Socio-environmental impacts of land use and land cover change at a tropical forest frontier

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EXTENDED ABSTRACT

Land use and land cover change, especially in tropical regions, have received much attention in recent years. Land use dynamics are usually caused by a combination of large scale drivers of change such as global markets or climate, but also region-specific forces like demographic change and regional/local policies. In the case study from Indonesia presented here, forests were replaced by agricultural land and agro-forestry plots. These processes were intimately linked with agricultural intensification and ongoing rural immigration. In this paper we used the integrated land-use model SITE (SImulation of Terrestrial Environments) to study the dynamics of major land-use and land cover types and quantify selected indicators of change. Analyzing the socio-environmental impacts of the agricultural transition process, we focused on the impact on gross margins of different crops as well as environmental impacts in terms of forest conversion and agricultural expansion. Simultaneously, we analyze the same indicators in a 'no migration' scenario to quantify the potential impacts of rural immigration. Results are communicated both to the scientific community and various stakeholders such as local farmers, political leaders and regional authorities.

Immigration into the study region in Central Sulawesi is occurring since the 1970ies, causing a population increase of 60% during the study period 1981 - 2002. Based on demographic trends of rural population, we developed a 'No Migration' scenario (NoMig) in which the population increased by 9%. During this period, the spatial extend of agricultural and agro-forestry land, including fallows increased by 47% during the historical period, while the cultivated area inside the Lore Lindu National Park (LLNP) increased by 200%. In the NoMig scenario agriculture expanded by 22% in the entire region, while the cultivated area inside LLNP increased by 70%. The by far largest expansion was observed in cocoa agro-forestry (12 fold), followed by coffee, fallows and settlement areas. Notably, the historical expansion of agricultural land used for the dominant staple food paddy rice was very moderate (20%) and even negative in case of the NoMig scenario (-12%). Since the early 1980ies, the gross margins per capita from agricultural production slowly increased from 1.2 Mio. Rupiah to 2.9 Mio. Rupiah in 2002. The gross margins of the NoMig scenario were generally lower, but followed the same general trend reaching 2.5 Mio. Rupiah in 2002.

Land-use dynamics in the study region are characterized by strong expansion of agricultural and agro-forestry land, and the consumption of natural resources, mainly primary and secondary forests. The livelihood of the rural population clearly improved during the study period, and the introduction of cocoa plantations provided additional economic benefits. The economic achievements are considered unsustainable, because they are based on forest conversion and an increase in unproductive fallow land. Major challenges in Central Sulawesi seem to be (i) to slow down the consumption and conversion of forest resources, and (ii) find means to regulate access to land.

The communication with stakeholders (e.g. dissemination of scientific findings) is facilitated by pathways of communication and mutual trust established during years of cooperation, both of which are considered at least as important as the technical and scientific aspects of integrated modeling. Potential limitations in communication with stakeholders are expected (i) to arise from conflicting interests of different stakeholders (and potentially scientists and stakeholders), (ii) lack of awareness and understanding of the concern and risks perceived by the respective parties, and (iii) a limited set of scenarios and indicators provided by our model.

1. INTRODUCTION

Land use and land cover change, especially in tropical regions, have received much attention in recent years (Turner *et al.*, 2001; Achard *et al.*, 2002; Lambin *et al.*, 2003; Priess *et al.*, 2007; Tscharntke *et al.*, 2007). Land use dynamics are usually caused by a combination of large scale drivers of change such as global markets or climate, but also region-specific forces like demographic change and regional/local policies.(Geist and Lambin, 2002) In the case study from Indonesia presented here, large areas of forest were replaced by cocoa agroforestry plots during the last two to three decades. These processes are intimately linked with agricultural intensification and ongoing rural immigration. Simultaneously, the food crop paddy rice, but also coffee agroforestry were loosing importance in the regional agricultural production systems. In this paper we used the integrated land-use model SITE Priess et al. (2007) to study the dynamics of major land-use and land cover types and quantify selected environmental and economic impacts. The results presented in this study enable both scientists and policy makers to analyze some of the consequences of regionally important policies such as (i) access to land, (ii) rural immigration and (iii) protection of the Lore Lindu National Park (LLNP) area. In addition, food security issues, which are more relevant on the national scale, can be assessed.

2. STUDY REGION

The study site is located in the province of Central Sulawesi, Indonesia and covers 7200 km². At the time of the field research, the region was divided into five kecamatans (= subdistricts) and 118 desas (communities), surrounding the Lore Lindu National Park (LLNP), which was established in the mid 1990ies, partly on land traditionally used by villagers. The provincial capital of Palu (approx. 300,000 inhabitants) is the most important market place and situated north of the northern most kecamatan Sigi Biromaru, which belongs to the tropical lowland zone, while the other four kecamatans belong to the sub-mountainous and mountainous zones (highest peak 2800 m.a.s.l.). The region is still dominated by forest cover (>80 % in 2002 according to Erasmi and Priess 2007), but increasingly used for agricultural production. Both inside and outside the LLNP, forests are used for the extraction of timber and other forest products such as rattan. Furthermore, forests are converted to agricultural land and agroforestry plots for subsistence and market production.

3. METHODS

3.1. Land-Use Change

Historical development and scenario analysis

This study covers the period from 1981 to 2002. As described above, various data sources were used to identify the most important land cover and land-use types, and quantify the land-use and land cover changes, which have occurred during the two decades. Based on land-use maps, which we established for 1981 and 2002 (following the method developed by Erasmi and Priess, 2007), we selected the most important land-use and land cover types according to their spatial coverage in 1981 and 2002.

The NoMig scenario is based on the assumption that immigration into the five kecamatans of the research area ceases in 1980, caused by restrictive policies of the provincial government in Palu and local leaders in the villages. To simulate the demographic changes of the NoMig scenario, we applied the population growth rates for rural population of Indonesia derived from the United Nation Population Division (UN Population Division 2006). The growth rates for rural population were applied to each kecamatan starting in 1980, to ensure that starting conditions were the same as during the historical development 1981 - 2002. Additionally, we applied results from our empirical studies, specifically the information that the knowledge how to grow cocoa was mainly introduced to the region by immigrants from South-Sulawesi. In consequence, the transition from strongly paddy-based subsistence farming including some coffee growing both for subsistence and the market, to coffee and more and more cocoa based market-oriented farming is much slower in the NoMig scenario than observed in the historical period. All other crops besides cocoa have been cultivated in the region for longer periods of time and follow the same trends as in the historical development. Table 1 provides a summary of the assumptions made for agricultural commoditeis in the NoMig scenario.

3.2. Land-use change modelling

Land use change was simulated with the latest version of the SITE model (SImulation of Terrestrial Environments) developed by Priess et al. (2007). The model has been developed as an integrative scientific tool in the context of the STORMA[1] project to be operated by scientists, not

[1] STability of Rainforest Margins; a long-term interdisciplinary Indonesian-German research project,

as a decision support system e.g. like FARMSCAPE (Carberry et al. 2002) or others. The main scope is to quantify scenarios of land-use change, which can either be driven by scientific questions (e.g. impacts of climate change, deforestation, or rural immigration) or stakeholder driven (e.g. by assessing perceived risks and concerns of farmers or local leaders in household and village surveys) or include both stakeholder and science questions. The feasibility to assist in decision-making is considered to be less an issue of operating the model, but to (i) communicate the features and limitations of the model and (ii) communicate the simulations results in terms of socio-economic and environmental impacts of different potential pathways of the recent past or into the future. Policy makers like the provincial government, the National Park authorities and local farmers have repeatedly demanded tangible results from STORMA scientists. As this was foreseen as part of the collaboration[2], so far, many research groups have presented their studies – mainly results from field work – in the form of leaflets and posters, but not yet including recent results from the SITE model. Thus at present it is still unclear, whether we will be able to translate e.g. modeling results, which are partly presented in this paper in a way, which is adequate i.e. credible and understandable for different stakeholders, and whether the desired feedback loop in terms of comments, suggestions and criticism from stakeholders can be established and lead to improved model parameters and scenario assumptions[3].

The SITE modeling framework is based on a cellular automata approach, in which the biophysical environment is represented by a regular 500 m grid. Four spatial scales are represented in the model: the grid cell level (29,024 units) – the village level (116 units) – the kecamatan level (5 units) and the entire research area (7,256 km²). Land use decisions are simulated once a year, while the growth of crops, estates and forests is simulated in daily time steps, using an adapted version of the DayCent model (Parton et al. 1998; Stehfest et al. 2007), including a new trace gas module developed by Stehfest (2005). Simulated land-use decisions are based on a multi-criteria suitability analysis of (i) the natural environment and (ii) the socio-economic conditions. Based on a sensitivity analysis, selected model parameters without sufficient empirical basis are calibrated using a genetic algorithm to minimize the difference between a reference land-use map for the year 2002 and the simulated map as decribed by Mimler and Priess (2007)..

The suitability of every land use type (and each crop) is calculated separately for every grid cell. The overall suitability is determined by the sum of biophysical suitability factors plus the sum of socio-economic suitability factors. The constraints potentially reducing the suitability are represented as biophysical and socio-economic (reduction-) factors.

After the suitability analysis, the SITE model allocates demands for all commodities in a hierarchical fashion. This task is carried out by the allocation modules, which check (i) whether a cell is eligible for land-use change, (ii) which is the optimal land-use for the present cell, and (iii) whether the transition from one land use to another is permitted. For example cells recently converted to crops carrying high establishment costs like coconuts or cocoa, can be converted only after e.g. 15 years, and thus are not eligible for change e.g. after 4 years. Additionally, the suitability of the new land-use type needs to surpass the suitability of the current type (i) to a predefined amount and (ii) for a number of years specific for each land-use type, mimicking the conservative behavior of farmers. The allocation hierarchy is based on regional allocation priorities (1. settlements – 2. crops and agroforestry – 3. managed and natural forests). Competition of different land-use types for favorable locations is simulated explicitly by the allocation algorithm, which identifies the local optima for all land-use types based on their overall suitability.

The allocation step is followed by the simulation of crop growth and the growth of forests and fallows. Environmental impacts derived from the biophysical models (e.g. changes in soil fertility, pollinator diversity or trace gas emissions) and socio-economic changes (gross margins, crop yields, etc.) are fed back to the decision algorithm to be taken into account in the suitability analysis and land-use decision simulated for the next year.

The results of village and household surveys and agricultural statistics of the historical period 1980 – 2001/2002 were also used to calibrate the simulated yields of all crops. Based on the same

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[2] STORMA was awarded as "best practice example" during the international conference "Achieving the Millenium Development Goals: a Challenge for Higher Education", Berlin – Germany, Nov. 03 - 04 2004

[3] Stakeholder panels, as a formal means to organize such a feedback (Alcamo 2001), were considered as too costly and time demanding, thus we have to rely on informal pathways and personal communication.

sources, crop-specific land use intensities in terms of multiple cropping, irrigation and fertilizer application rates were implemented for every kecamatan. Note that fertilizer applications in cocoa agroforestry and the cultivation of paddy rice are taken into account as variable costs, while transportation costs and conversion or establishment costs were applied for all commodities.

4. RESULTS

4.1. Population Growth and Immigration

In Sulawesi, highest net rates of immigration are found in the province of Central Sulawesi, followed by Southeast Sulawesi, while South and North Sulawesi are characterized by net outmigration (BPS 2001).

At the latest since the 1970ies the influence of inter-region migration on the population development in Sulawesi rose respectably. The population of Central Sulawesi increased by only 14% between 1930 and 1970 but by more than 41% during the period 1970-1980 (own calculations based on Kruyt 1938, and BPS 1971, 1981). In the research area, which comprises five kecamatans of Central Sulawesi, the population increased by 60% during the period 1981 - 2002. Large intra-regional differences in population growth were observed, ranging from 29% in Lore Selatan to a tripling of the population in Lore Utara.

Based on the annual growth rates for the rural population of Indonesia provided by the Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2006), and the regional population statistics (BPS 2004), we calculated the hypothetical size of the population without rural immigration, based on the population data of the year 1980. We estimated that during the 80ies and 90ies the rural population would have increased by 7,000 people (9%) without immigrants, while 37,000 people immigrated into the region, (assuming identical fertility and mortality rates of autochthonous people and migrants). Large differences in immigration rates between the five kecamatans could be observed. Sigi-Biromaru, Palolo and Lore Utara were subject to high immigration rates, while the rates calculated for Kulawi were lower and almost neglectable for Lore Selatan. In the following chapters we will link the demographic trends of the historical development and the NoMig scenario to land-use dynamics, biophysical and economic indicators.

4.2. Land use change

The spatial extend of agricultural and agro-forestry land, including fallows increased by 47% during the historical period, while the cultivated area inside LLNP tripled from 3,000 ha in 1981 to almost 9,000 ha in 2002. In the NoMig scenario agriculture expanded by 22% in the entire region, while the cultivated area inside LLNP increased by 70%. Thus, in both cases the expansion of agriculture and agro-forestry within the protected areas was much faster than the general trend.

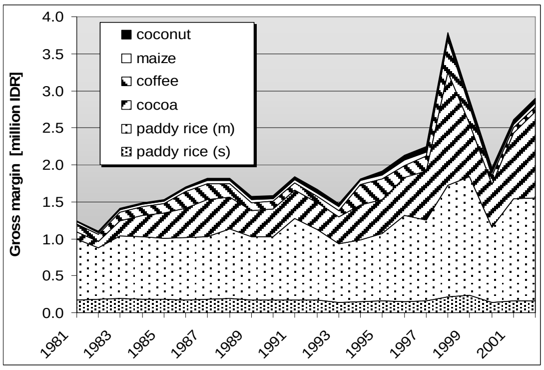
Table 1: Land-Use Change 1981 - 2002

Land Use Type	**Historical Changes [ha]**	**NoMig Scenario [ha]**
Forest	-28,150	-12,075
Cocoa	16,950	5,500
Coffee	4,350	2,550
Coconut	175	-275
Fallow	5,875	10,100
Grassland	-3,825	-2,075
Maize	-2,275	-1,700
Paddy rice	4,100	-2,475
Settlement	2,800	450

As Table 1 shows, the contribution to land-use change varied considerably between land-use types. The by far largest expansion was observed in cocoa agro-forestry (12 fold), followed by coffee, fallows and settlement areas. Notably, the historical expansion of agricultural land used for the dominant staple food paddy rice was very moderate (20%) and even negative in case of the NoMig scenario (-12%). The spatial extend of settlements, (including infrastructure, public buildings and home gardens) doubled, but increased only by 20% in the NoMig scenario. The dominant land cover ‘forest’ including secondary and managed forests was reduced by 4%, while in the NoMig scenario forests lost 2% of their coverage, which is equivalent to 20,500 ha and 10,500 ha respectively. Large differences were observed between the five kecamatans, in which deforestation summed up to more than 13% of the low land forests of Sigi Biromaru in the North, while in the South-East less than 1% were converted in Lore Selatan.

4.3. Economic impacts

Our simulations are based on producer prices paid in Indonesia, as constant Indonesian Rupiah, base year 2000. While the prices of cocoa and especially of coffee were highly volatile, prizes for maize and coconuts (copra) increased steadily, with a minor depression at the end of the 1990ies. Prices for paddy rice paid in the provincial capitol, the city of Palu, remained stable almost over the entire period. Contrasting to falling prices of all other commodities, the rice price increased for three years during the late 1990ies, before it fell back to the original level in the year 2000.



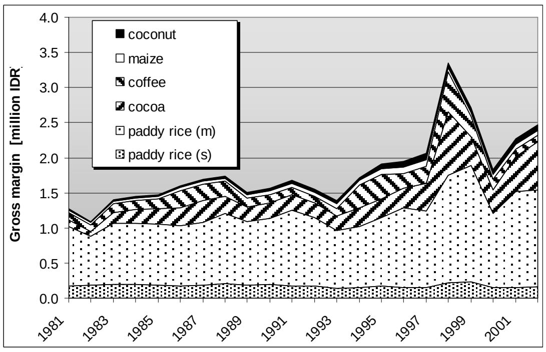


Figure 1. Per capita gross margins from agricultural production for the period 1981 – 2002. **Upper**: historical period; **Lower**: NoMig scenario; (m) indicates market production, (s) indicates subsistence production

In Sulawesi traditional agriculture was based on paddy rice some maize and vegetables, of which the latter are not subject of this study. After Indonesia became independent in 1945, first coffee and later cocoa were introduced as cash crops. Agriculture was and still is also the main source of income for most of the rural households (Schwarze and Zeller 2005). Since the early 1980ies, the gross margins per capita from agricultural production slowly increased from 1.2 Mio. Rupiah to 2.3 Mio. Rupiah until 1997, when a sharp increase followed by a more pronounced sharp decrease disturbed the trend, while the last three years until 2002 gross margins recovered and finally surpassed the mid 90ies level and reached 2.9 Mio. Rupiah in 2002 (figure 1). The gross margins of the NoMig scenario were generally lower, but followed the same general trend reaching 2.5 Mio. Rupiah in 2002. On average in the entire research area the gross margins in the historical past were 10% higher than in the NoMig scenario (15% in the last years). Contrastingly, due to a high fraction of cocoa, the income generated in the protected forests of LLNP was twice as high in the historical past than in the NoMig scenario.

During the study period the importance of maize and coconuts remained low, while the contribution of paddy rice and coffee decreased and the one of cocoa increased. In the NoMig scenario, the contribution of coffee remained higher, while the contribution of cocoa increased slower than in the historical past. The fraction of paddy produced for subsistence varied between 11% and 20% in both cases.

5. DISCUSSION

5.1. Migration

Information networks within the ethnic groups between pioneer migrants and their families, which were still living at the places of origin, facilitated the succeeding chain migration to the forest frontier zones of Central (and Southeast) Sulawesi. Besides the disparities of land availability between areas of origin and areas of destination, the migrating farmers' knowledge about the cultivation of cacao and their financial potential to purchase land are major driving forces of the increasing migration since the late 1970s to those regions, where the environmental conditions are favorable for cocoa cultivation (Akiyama et al. 1996; Li, 1999; Ruf & Yoddang 2001). Additionally, higher average commodity prices for cocoa (10,000 IDR / kg), as compared to lower and even more volatile coffee prices (6,500 IDR / kg) contributed to the successful establishment of cocoa plantations and the decreasing attractivity of the already established cash crop coffee. As Weber et al. (2007) could show, the impact of migrants on deforestation is mostly indirect, as they tend to buy land from locals, rather than to cut the forest themselves. As a consequence, locals either replace the land sold, opening new plots for agriculture or agro-forestry, or move on to new forest frontiers. Thus, the social and economic status of migrants in Central Sulawesi differs considerably from those of migrants e.g. reported from Amazonia and Central America (Lopez, 2004; Renner et al., 2006). Local leaders or village headmen frequently seemed not only to be involved in land transactions, but to benefit from legal and illegal transactions, which might partly explain the "open access" policies observed in many villages, and the policy failure in protecting the LLNP.

Contrasting with the historical development, the alternative NoMig scenario is not only based on different immigration policies at the village and kecamatan level, but assumes the continuation of a more traditional food-crop and subsistence oriented land-use strategy and life style, which is still to be found to date in the remote corners of the study area, in villages which are only connected via foot-paths to the rest of the world. The environmental and economic consequences of the two different live styles are discussed in the following paragraphs.

5.2. Land-Use Change

During the study period three different process of land use change were occurring simultaneously. Firstly, agricultural land use was intensified, mainly with respect to fertilizer use, a practice which started in the 1990ies. Simultaneously, a slowly advancing mechanization with two-wheeled hand tractors occurred around the same time, tractors mainly used to prepare paddy fields (not simulated). Secondly, crop land and agro-forestry land were expanded, mainly on the expense of forests. The conversion of land cover and land use occurred not only on protected and unprotected forest land, but also from agricultural land to agro-forestry land. The latter type of conversions occurred in the context of the third process, the transition from a traditional, mostly subsistence oriented production of food crops towards an increasing production of cash crops. (It is noteworthy that fertilizer subsidies intended for the stimulation of paddy rice production were found to be applied on cocoa plantations.) A larger fraction of the new cocoa agro-forestry plots (as compared to the average agricultural expansion) was established within the LLNP. The fact that the gross margin per hectare for cocoa is higher than for agricultural crops, explains why the differences in per capita gross margins between the two scenarios are much higher in the National park (more agro-forestry) than outside (more agriculture). The still large fraction of forest cover and - as a consequence - the relatively low forest conversion rates, conceal the highly dynamic agricultural expansion, which have caused an almost 50% increase of agricultural land in the research area and an extraordinary increase of 300% increase inside the National Park.

During the period 1981 – 2002 the forest conversion rates in Sulawesi appear still moderate when compared to other tropical regions e.g. Central America where 23% of forest were converted in the same period (Carr et al. 2006). However, large scale studies and assessments may mask or overlook regional sets of socio-environmental drivers and conditions (presented in this study, or e.g. reported by Renner et al. 2006 from Guatemala), which might enable us to identify options to mitigate unsustainable land use, for example pathways to increase the still low technical efficiency of cocoa agro-forestry as proposed by Keil et al. (2007).

Comparing historical agricultural expansion to the one calculated for the NoMig scenario, reveals that immigration is directly or indirectly (via activities of the local population) related to deforestation, especially inside the LLNP. Obviously, local and regional authorities did not succeed in protecting the LLNP. This lack in protection was clearly reflected during calibration runs of the SITE model, during which the conceptual 'park protection parameter' was repeatedly set to values close to 0 by the calibration algorithm, indicating 'no to low protection' of the LLNP forests.

5.3. Economic impacts

At the beginning of the study period the agricultural production was mainly subsistence oriented and predominantly based on paddy rice. However, during the entire period, food security – which is a permanent concern of the central government – was never endangered, as the fraction of paddy rice needed to feed the local population varied from 11% - 20% of the regional production, assuming a per capita annual rice consumption of 131 kg (see BPS). In Figure 4 the fraction of gross margin used for subsistence has been calculated based on the assumptions that 90% of the rural population was engaged in paddy rice production in 1981, a fraction linearly decreasing to 60% in 2002 (to 70% in the NoMig scenario). If we take subsistence rice consumption into account, per capita gross margins have to be reduced on average by 9% (up to 19% at the beginning, and 6% towards the end of the period).

During the study period, the per capita gross margins of agricultural commodities increased more than two-fold, a fact which can be assumed to be the most important economic impact of land-use / land-use change. Comparing the historical past and the NoMig scenario, the previous clearly benefited from the introduction of cocoa plantations, which can mainly be attributed to the knowledge of immigrants from South-Sulawesi. Considering an average household of 5 persons, gross margins would sum up to 14.5 Mio. Rupiah in 2002, which is equivalent to 1,320 Euro, and 1,120 Euro or 15% less in case of the NoMig scenario (exchange rate IDR - €: 11,000). In other words, rural households on average profited 200 Euro per year from the ongoing immigration. We are aware that this calculation is a strong simplification, for example not taking into account environmental damages, nor income distribution between locals and migrants, nor other factors. However, the estimates provide us with a means to evaluate some of the economic impacts of rural immigration in Central Sulawesi. Not only immigrants, but also adaptive locals were benefiting from the cocoa boom. However, both Li (2002) and Weber et. al. (2007) highlighted the complex economic and social transformations going hand in hand with land-use change and immigration, and which are partly causing tensions between ethnic groups. Additionally, pests and diseases are increasingly affecting the quality and quantity of cocoa yields and thus the profit of cocoa growers, and Neilson (2007) poses the question whether or not the economic benefits for the cocoa growers of Sulawesi can be sustained or will follow the decline which has occurred e.g. in Brazil and Malaysia.

6. CONCLUSION

In this paper we presented a study on land-use dynamics and selected socio-environmental impacts in Sulawesi, Indonesia. We used the integrated land-use model SITE as a tool to simulate historical land-use change and an alternative No Migration scenario. The modelling framework was capable to process relevant driving forces and to simulate major components of and impacts on the socio-environmental systems of Central Sulawesi.

Land-use dynamics in the study region are characterized by strong expansion of agricultural and agro-forestry land, and the consumption of natural resources. While the livelihood of the rural population clearly improved during the study period, and the introduction of cocoa plantations – mainly triggered by the knowledge and the capital of immigrants - provided additional economic benefits. The economic achievements are considered unsustainable, because they are based on forest conversion and an increase in unproductive fallow land. Major challenges in Central Sulawesi seem to be (i) to slow down the consumption and conversion of forest resources, and (ii) find means to regulate access to land. In addition, it seems essential to reduce the growing impacts of pests and diseases in cocoa agro-forestry in order to avoid the classical cocoa pathway of 'boom and bust' as depicted by Neilson (2007).

In the context of the STORMA research project, the dissemination of scientific findings is facilitated by pathways of communication with villagers and authorities and mutual trust established during several years of cooperation. Following Matthews et al. (2006) the established social structures are considered at least as important for communication than technical and scientific aspects of the SITE model. Potential limitations in communication with stakeholders are expected (i) to arise from conflicting interests of different stakeholders (and potentially scientists and stakeholders), for example the regional government and local farmers on the topic of agricultural expansion, (ii) lack of awareness and understanding of the concernS and risks perceived by the respective other parties, and (iii) a limited set of scenarios and indicators provided by SITE, (of which only a subset has been presented in this paper).

The current discussion among STORMA scientists how to communicate simulation results like the ones presented in this paper, includes aspects of (i) whether or not to confront stakeholders with (il)legal aspects of land-use change, (ii) whom to address from the large and very heterogeneous group of stakeholders, (iii) which format would be appropriate (narrative, tables, maps, images) and to which degree risk perceptions of stakeholders - which are currently evaluated - should be discussed before integrating them into scenarios of the future. We currently discuss to use the 'good news' about recent economic benefits discussed in chapter 5.3, to transport the message both to farmers and politicians that e.g. the negative impacts discussed in chapter 5.2 and other factors could affect a large number of communities. However, we not only want to inform stakeholders about scientific results, but also seek their assistance and advice to (i) address perceived risks in the scenarios and (ii) identify potential pathways into the future decreasing socio-environental costs and increase the benefits for example via improved efficiency (Keil et al. 2007) and better control of agricultural expansion.

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