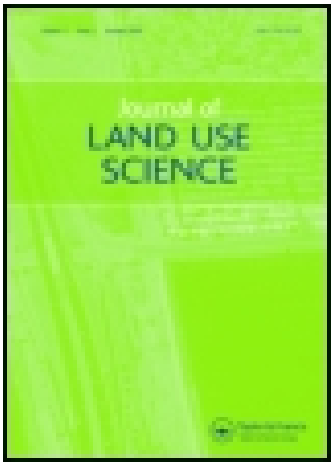

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Proximate causes and underlying driving forces of land-use change among small-scale farmers - illustrations from the Loess Plateau, China

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Proximate causes and underlying driving forces of land-use change among small-scale farmers – illustrations from the Loess Plateau, China

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Small-scale farmers on marginal land in the Loess Plateau of China are adapting their livelihood to new situations and changes such as varying climate, new land-use policies, changing employment opportunities and new market situations. To avoid generalising explanations with regard to land-use change, interactions between proximate causes and underlying driving forces adopted from a meta-analysis model are explored through 23 in-depth interviews. This was done through collaborative work with farmers in northern Shaanxi Province and focused on the land-use situation between 1982 and 2005. The result reveals five categories of land-use change. The interaction pattern is broken down into eight proximate causes and four underlying driving forces. The dominant underlying driving forces are economic forces with short time horizons arising partly from compensation through policies, changes in crop demand from an expanding nearby market and a need for cash because of an increasingly cash-based lifestyle. The direct proximate causes were vividly described by the farmers as tools or means by which they are adapting to more abstract and indirect factors. These factors were identified as underlying driving forces. Hence, the knowledge and ability to separate the interaction into proximate causes and underlying driving forces are crucial in policy-making.

Keywords: land-use change; drivers for change; climate variability; globalisation; interviews; Shaanxi Province

Introduction

Land-use change is a major contributor to global environmental change; yet, the understanding of drivers of change to this human–nature interface is not fully understood. This is mainly due to the non-linear and complex linkages between processes (Geist and Lambin 2002). Efforts to formulate these links have generally used either broad-scale cross-sectional analysis based on national statistics or detailed case studies on a local scale (Geist *et al*. 2006). Within the Land-Use and Land-Cover Change (LUCC) project in the International Geosphere-Biosphere Program (IGBP) and the International Human Dimensions Programme on Global Environmental Change (IHDP) the aim has been to apply a middle path that combines the two: the richness of qualitative in-depth case studies or data with the power of generalisation gained from larger and quantitative samples, as described in Meyfroidt and Lambin (2008). This paper uses one of the models that was developed

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through the LUCC programme to conceptualise drivers behind land-use change in a new context.

Earlier studies conducted in Northern Shaanxi, China, indicate a complex system of several factors driving land-use change at household level (Hageback and Sundberg 2002; Knutsson *et al*. 2003; Ostwald *et al*. 2004). Single-factor explanation on a local scale has long been seen as inadequate when discussing land-use change because of the interaction between physical land transformation and its social drivers (discussed by Turner *et al*. 1994). Multiple factors influenced change in the northern Shaanxi Province. Firstly, a change in climate or climate variability has taken place over the last 30 years. This has been characterised by a significant increase in temperature, mainly during the winter, and erratic and slightly decreasing rainfall (Hageback *et al*. 2005; Ostwald and Chen 2006, also see Figure 1).

Secondly, there was the introduction of the Cropland Conversion Program (CCP) converting slope land exceeding a gradient of 25° from agricultural land into tree plantations or grass land (Rui *et al*. 2001; Ostwald *et al*. 2007). Thirdly, there was the increased availability of off-farm activities that generated more income for farm families than agricultural activities. Fourthly, the Loess Plateau region has also been a focus of environmental effects of reforms and policies, especially following introduction of the Household

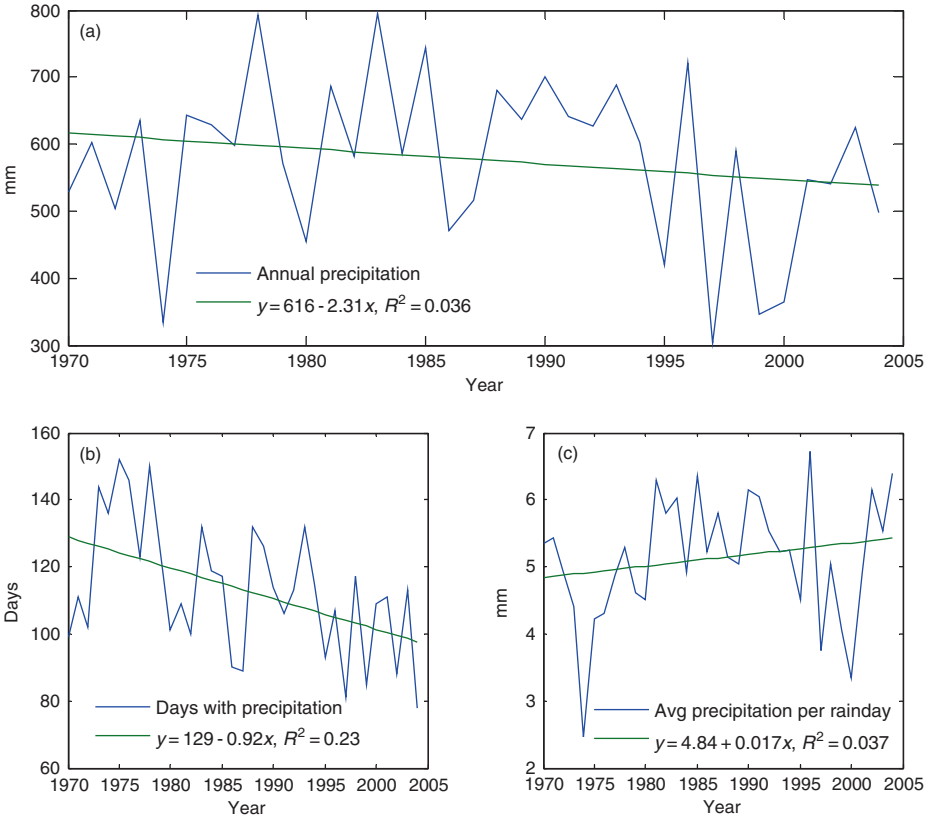

Figure 1. Precipitation tendencies in Ansai 1970–2004, (a) total annual precipitation, (b) number of days per year with precipitation, (c) average amount of precipitation during a 'rain-day'.

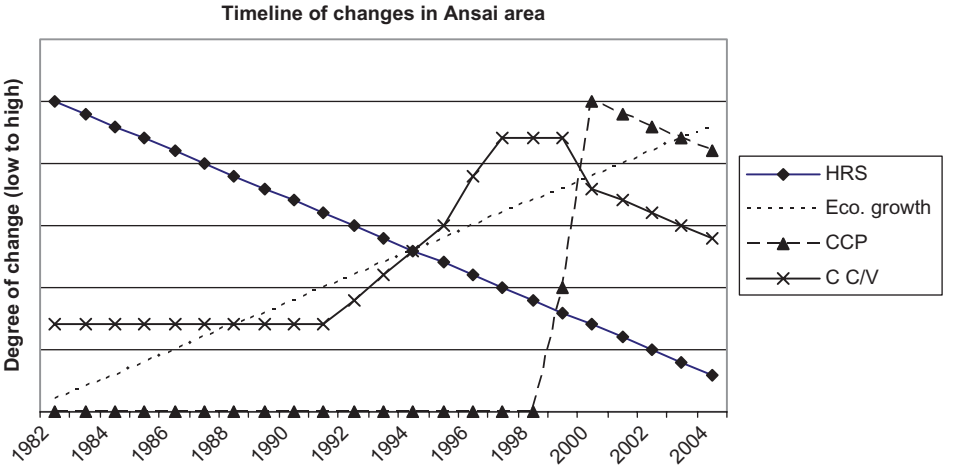

Figure 2. Schematics of different changes that farmers in Ansai have been exposed to from 1982 to 2004. The degree of change is unitless and is the general experience among land users. HRS – Household Responsibility System, CCP – Cropland Conversion Program, C C/V – Climate change/variability.

Responsibility System (HRS). The HRS was introduced in this area around 1982 and included short-term land-use responsibility with 15-year leases. This made land users focus on short-term returns and also resulted in an increased area of abandoned damaged land (Hu 1997; Li and Sun 1997; McElroy *et al*. 1998; Liu 1999; Skinner *et al*. 2001). Based on previous research, these different changes and their interactions can be explained over time schematically, as in Figure 2, where the degree of change is the general and conceptually unit-less experience of land users in the area.

Land-use change is defined as change of a particular usage, e.g. from crops to trees, from subsistence crops to cash crops or crops to greenhouses, or technical innovation, such as fertiliser usage, plastic covers or irrigation. Over time, these changes in land use can alter the vegetation status. For example, tree plantations were initially a land-use change and will continuously increase the vegetation of the land, leading to changes in land cover.

The area around Ansai in northern Shaanxi is well documented in terms of agricultural activities, climate variability and land-use change (e.g. Chen *et al*. 2001; Fu *et al*. 2003; Knutsson 2004; Ostwald *et al*. 2004; Hageback *et al*. 2005; Ostwald and Chen 2006; Ostwald *et al*. 2007). Studies with similar scopes on drivers behind land-use change have been conducted in China (Li and Sun 1997), but were based on official statistics at the county level; this study focuses on the farmers' data at the household level.

Objectives

The overall aim of this paper is to analyse proximate causes and underlying driving forces that small-scale farmers specify in interviews as the cause of land-use change during the last few decades and how these drivers are linked by using the model from Geist and Lambin (2002, 2004) and Keys and McConnell (2005). Furthermore, we differentiate between proximate causes and underlying driving forces based on the ongoing process that farmers are facing by highlighting the outcome of land-use changes that have taken place according

to the farmers. Finally, we discuss the need for different levels of drivers when using the model as a tool for decision-making.

The model of proximate causes and underlying driving forces

Through the use of meta-studies, land-use scientists have explored empirical data to understand the drivers for land-use change for tropical deforestation (e.g. Lambin *et al*. 2001; Geist and Lambin 2002; Lambin *et al*. 2003), tropical agriculture (Keys and McConnell 2005) and desertification (Geist and Lambin 2004). One of the aims of these types of studies has been to avoid generalisations based on dominant theories or the description of single explanatory primary causes based on data from national statistics, which has often been used in land-use studies (e.g. as described in Lambin *et al*. 2001). Furthermore, there is a need to understand the role of different levels of drivers and their inter-linkages from the perspective of policy implementation. Land-use change is typically driven by multiple factors acting simultaneously or by underlying driving forces that in essence drive the factor which is seen to be the driver. Also, land-use change is seldom the result of a single action but is often associated with several changes, resulting in a chain of land-use changes. These characteristics make identification and explanation of drivers of land-use change very complex. With complexity comes the risk that the explanatory models become as many as the cases that are studied due to local variation; this calls for a conceptual model.

The concept of proximate causes and underlying driving forces from former studies (e.g. Geist and Lambin 2002, 2004; Keys and McConnell 2005) will be used in this analysis, because it systematically assesses the two different classes of drivers behind land-use change. Proximate causes are generally human activities or immediate actions at the local level that have direct impact on land cover and land use. These factors are the direct reason for land-use change, but to explain the reason for the proximate causes, underlying driving forces have to be assessed. The word 'causes' will be used to describe the direct explanatory reason for land-use change, whereas 'underlying forces' will be used to describe the more indirect reasons. 'Factors' and 'drivers' will be used as umbrella terms for anything creating land-use change.

Using the meta-analysis model in a new environment and new types of data collected through qualitative interviews reveals several distinct differences that are worth pointing out. Our focus is on land-use change among small-scale farmers in marginal agricultural lands in semi-arid China. Due to this, our data are collected together with land users at household level and the analysis is in micro-scale. One of the limitations of the original models was that trends were not well represented (see Rudel 2005). In our analysis of change among small-scale farmers in China, we use a process-based explanation (described in Figure 2) that inherently includes trends of different time-dependent changes. This means that several changes are known and described before the analysis, which makes the known processes of change and some of the analysed drivers in the model less distinct. In addition, we do not quantify the changes as single or multiple in character because of the limited number of cases; however, we present the different phenomena as described by the farmers.

The setting

This study focuses on the areas around Ansai in the northern Shaanxi province (Figure 3). The area is characterised by loess with heavily eroded slopes (Figure 4). To come to terms with erosion and consequently the sedimentation of the rivers downstream, the government

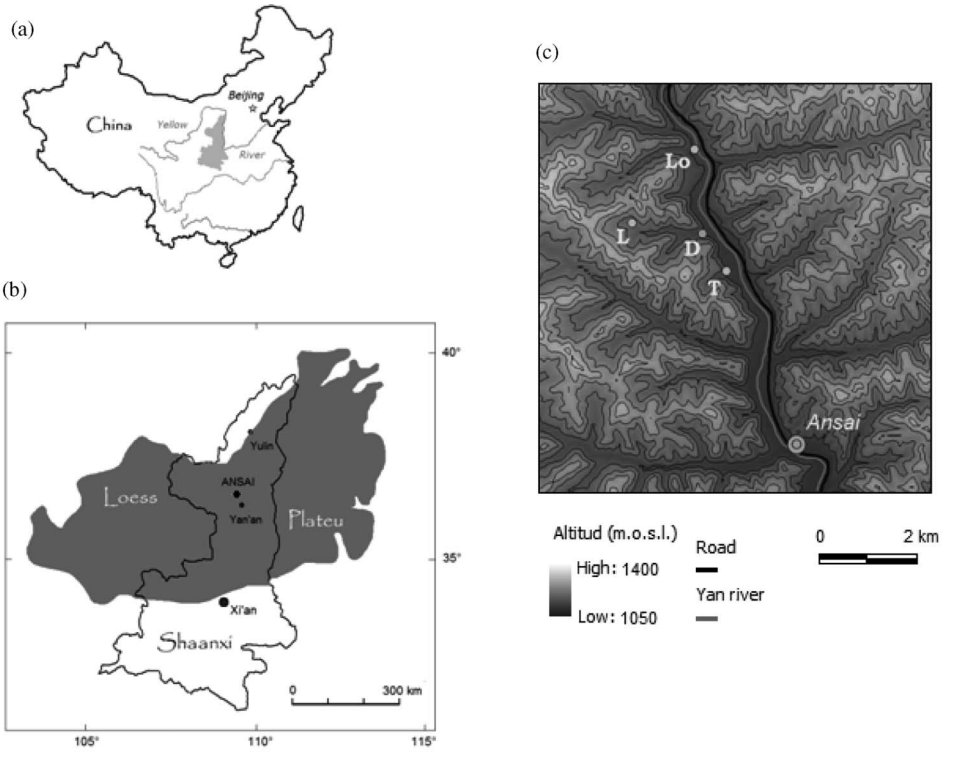

Figure 3. (a) Shaanxi province's position in China, (b) Ansai's position in Shaanxi with indicated Loess Plateau extent and (c) topographic map of the study area. The positions of the villages in which interviews were conducted, Longan (Lo), Leipingta (L), Danangou (D) and Tu Chuan (T), are indicated by capital letters. The new highway runs along the west side of the river.

Figure 4. Tree plantation under the Cropland Conversion Program has changed the land use for a majority of the interviewed farmers. The erosion in the Loess Plateau is characterised by deep gullies.

executed the Sloping Land Conversion Program, or as described in Shaanxi Province, the CCP. The programme has been implemented throughout the study area.

Data collection and analysis

The data were collected through in-depth interviews using an interpreter in 23 households in four different villages in the Ansai County (Figure 3) in 2005. The interviewees were selected in consultation with the head of the village and based on several criteria. The age of the farmers was important because the farmers needed to have farming experience before or since the changes to the land tenure system were implemented, i.e. 1982. A second criterion was based on income level or perceived wealth because both farmers with small financial means and few resources and those who were better-off were sought. Qualitative interviewing was chosen because the method enables informants to elaborate their arguments and allows the expression of paradoxes and ambivalence (Kvale 1996). In addition, qualitative interviews generate data that provide an authentic insight into people's experiences (Silverman 1993). In-depth interviews can be seen as a good complement to the quantitative studies used earlier for the model (Geist and Lambin 2002, 2004; Keys and McConnell 2005). The in-depth material allows us to analyse narratives gathered from the informants' own ways of describing the situation. This can in turn be related to the broader and more generalised approach provided by the model. The aim of the interviews was to explore the informants' narratives about the period from 1982 up until 2005.

The first stage was to determine what land-use changes occurred during this period. The next stage was to collect data on the possible drivers of these changes. With the information about each household's land-use history, reasons for these changes were sought through further interview questions to the farmer and with help of discussions around land quality, yield, family structure, weather and income.

The data from the interviews were analysed by means of thematic content analysis (e.g. Wibeck 2004). The first step in the analysis was to identify types or groups of land-use change, i.e. the analysis was data-driven. The second step was to compare the findings with the proposed categories in the model to identify proximate causes and subsequently to discuss underlying driving forces. The difference between the two was found in the structure of the interview, where the actual change stated by the farmers was followed with the reasons for this change, which were then used as the proximate causes of the change. From this point, the reasons for the change were discussed by estimating their importance. A description of contextual factors was obtained and used to identify underlying driving forces. This procedure allowed the identification of additional categories as well as in-depth insights into the informants' surroundings.

The changes

Apart from land-use changes, farmers in the Ansai area have experienced a variety of changes over the last two to three decades (as described in Figure 2). These changes will be described below to put the farmers' plight into context.

Climate variability

The temperature has increased since the 1970s, notably in the winter and spring. This has been accompanied by decreasing and erratic precipitation. Changes in the precipitation patterns are shown in Figure 1 and illustrate (a) a decreasing trend, even though it is not

statistically significant because of the high variability, (b) a decreasing number of days with precipitation and (c) the amount of rain for each of those days. From a farming perspective, the combination of the latter two patterns is a negative development, because water availability is crucial and higher rainfall intensity is closely associated with erosion. The temperature has increased significantly in Ansai, at a rate of 0.3°C per decade since 1970. Although increasing mean temperatures can lengthen the growing season, it causes soils to dry out through evapotranspiration, particularly in the spring. This adds stressors to rainfed crops.

Household responsibility system

The HRS was introduced in this area of China in 1982. The government decided to resolve the communes that had been operating since the 1950s, and land-use rights were again distributed to individual farmers who could choose what to plant, often according to the market demand. The rights to the land were based on a leasing system of 15 years. The absence of long-term responsibility and the resulting negative impact on the land and natural resources subsequently made the government extend the leasing term to 30 years, commencing slowly in 1998 and becoming more comprehensive in 2002 (Keliang and Prosterman 2006).

Cropland conversion program

In 1999 the Chinese government introduced the Slope Land Conversion Program at national level, also known as the Grain for Green Policy (see Feng *et al*. 2004), and later named the CCP at the provincial level in Shaanxi. The policy had a budget of over 40 billion US dollars (Xu *et al*. 2004) and can be seen as one of the most ambitious environmental initiatives globally. The objective was to halt erosion, and indirectly to solve the problem of sedimentation in the big rivers, by encouraging farmers to convert from crop cultivation on slopes to tree and grass plants. The CCP is essentially a Payment for Environmental Services (PES) scheme. The programme provides compensation to farmers in the form of money and food grains for up to 8 years. The targeted land for Shaanxi Province was slopes with gradients exceeding 25° and included the planting of mainly locust trees (*Robinia pseudoacacia* L) (Rui *et al*. 2001).

In the Ansai area there has been a roughly 75% reduction in cultivated agricultural land area. Based on these findings, described by Hageback *et al*. (2005) and Ostwald and Chen (2006), the process can be described as a flow of changes, as shown in Figure 5. The changes include both land-use change and changes in livelihood.

Economic change

China has undergone a dynamic phase, with an annual economic growth averaging 9.4% since 1978 (Kuijs and Wang 2006). The starting point for these changes can be traced to the 1978 economic reform that opened up China to the outside world market in a controlled way, a change forced by years of economic stagnation (Lu and Wang 2002). The open-door policy made China take part in the increased globalisation (Yeh and Li 1999; Bao *et al*. 2002) with a gradually increasing trade in agricultural products. Even though the concentration of these activities were localised along the coastal-city areas, giving China an uneven distribution of regional economic development, trickle-down effects of the economic development are also found in interior and rural parts of China (Knutsson 2004).

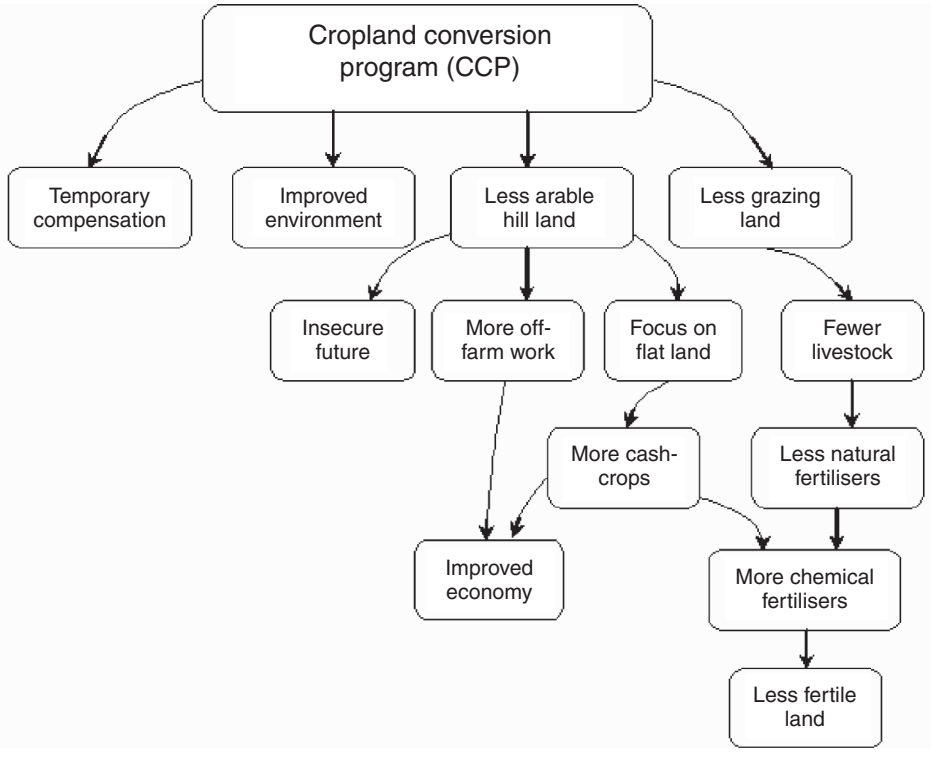

Figure 5. A conceptual flow-chart of the impact of the cropland conversion program among small-scale farmers in the semi-arid northern Shaanxi province.

Locally, the farmers have recently been engaged in more off-farm work than they had 20 years ago. There are two main factors that explain this. Firstly, the CCP and the associated decrease in active agricultural land allow farmers to spend less time in the field. Consequently, time has been found for other income-bringing activities. Secondly, the expansion of the city of Ansai and the construction of a highway through the county enhanced the opportunities for off-farm jobs. This new situation has greatly affected the sources of income for farming households. These changes have been welcomed by farmers because of their desires for lives that are unrelated to farming. Furthermore, the new lifestyle is seen as being 'better' than the previous one, because there is greater economic freedom and availability according to the farmers. This reflects the increased accessibility of different markets, in terms of both commodities and work.

In this complex web of changes there are many uncertainties regarding how, for example, climate change and variability will impact agriculture and how farmers will respond to this (Reilly and Schimmelpfennig 1999). Simelton (2007) has attempted to study these changes with the aid of 50 years of climate and agricultural data as well as a crop model. The study, which focused on wheat production in Shaanxi, estimated that over a 50-year period only 5% of the yield increase was due to climate change, whereas the climatic impact appears to have increased since the 1990s. The rest of the increase in yields was explained by non-climatic factors such as technological changes and management practices. The human factor was therefore crucial.

Results

Land status: 1982 versus 2005

When the HRS was implemented in 1982 the farmers cultivated practically all land they were allotted. Later on, the farmers noticed that they were producing more crops than were needed for their own families. Consequently, some of the most remote or less fertile land was abandoned to reduce the workload.

Today, the average size of land area per household in the investigated region is 29.1 mu, which is approximately 1.9 hectares (1 mu = 667 m^2) (Table 1). The most striking figure is the decrease in the amount of cultivated land (–89.9%); this is mainly due to CCP. The land used for CCP is primarily located on the hillside but is still under the management of the individual farmers.

A large part of the land that was excluded from farming consists of productive flatland (–57.6%). In this case, the main reason for the exclusion was the construction of the highway in the bottom of the main valley. Arable flatland has also been used for housing to a lesser extent. In addition to a growing population, there is also a desire to have larger and more modern houses. One interviewee described how the family used large parts of their flatland for this purpose when their son got married.

Land-use rights have also been transferred between the farmers in a rather complicated way. One interviewee transferred roughly three-quarters of his land to another villager during the 1990s, which was used for a large fruit plantation. This decision was not optional because it was made by the authorities and the compensation offered was far below the market value. According to the farmer, other villagers had experienced similar forced transfers.

Changes in crops

In 1982, all households cultivated millet and soya beans (Figure 6). Besides these crops, most farms grew potatoes, corn and traditional drought-tolerant crops such as foxtail millet and buckwheat. A small number of the interviewed farmers were growing vegetables in 1982. This situation has completely changed. In 2005, soya beans and millet were being cultivated by a few and none of the farms were growing buckwheat.

Although typical staple food is cultivated by few farmers and on small areas, the situation is the opposite when it comes to vegetables, the cultivation of which has been driven by a rising commercial demand. Vegetables are most commonly grown on the flatland, which is the land that is in cultivation after CCP.

Table 1. Average amount of land per household divided into land based on topography as well as management practices and its change between 1982 and 2005 (n = 21). The unit is ‘mu’, 1 mu is equivalent to 667 m^2.

	Total land	Hill land	Flat land	Cultivated land	Terraced land
1982	32.3	29.2	3.1	31.6	–
2005	29.1	27.8	1.3	3.2	1.4
Change	–9.9%	–4.8%	–57.6%	–89.9%	

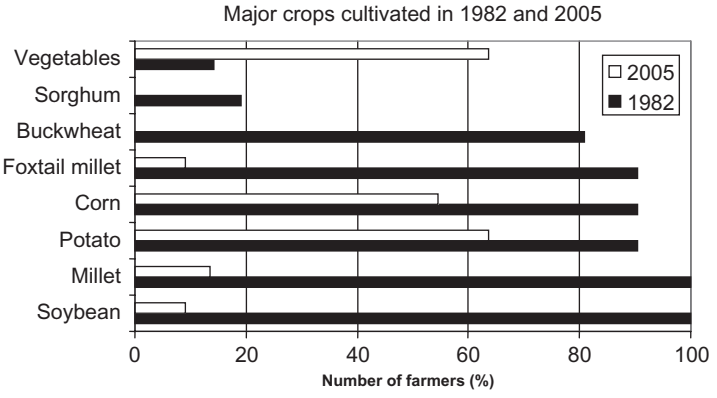

Figure 6. The major crops cultivated in the villages and the percentage of the interviewed farmers who cultivated them in 1982 and 2005 (n = 21).

Proximate causes and underlying driving forces

Based on the material collected from the farmers, a variety of different land-use changes were identified (Figure 7), some of which have been discussed above. The land-use changes that the farmers reported were clustered into five groups: natural changes, construction changes, agricultural practice changes, external changes and livestock changes. These changes were explained by the farmers with an array of proximate causes which can be classified into eight categories: financial, government recommendations and restrictions, weather conditions, technology, demographics, livestock, management practice and plant and soil. To explain these proximate causes, the underlying driving forces were further grouped into four main headings: economic, policy, cultural and climate drivers.

The most striking result is that the vast majority of underlying driving forces are associated with economic factors for the farmers. The farmers' choices are clearly driven by factors that generate economic benefits. Most of these benefits are predicted to accrue in the near future, with 12 years being the most realistic time-frame.

The underlying driving force of climate was described by farmers in association with economic benefits. For example, milder winters shown in Figure 7 are generating the increased use of greenhouses. This was described as a driver by farmers because (a) vegetables could be grown all year around and (b) the price of vegetables were higher in the winter season, which was positive for the producers.

Two different households provided examples to illustrate the different levels of drivers and possible inter-linkages found in the data (Figure 8). The first household stated one distinct land-use change between 1982 and 2004, namely the introduction of fertilisers and pesticides into the farming process. The proximate cause was the desire to increase the vegetable yield. The underlying driving force behind this desire was to earn more money and hence the means with which to buy food and other commercial items.

In the other household a more complex picture evolved. Three actual land-use changes were listed: the introduction of tractor use, the introduction of fertilisers and the slaughtering or selling off of livestock. The proximate cause, buying a tractor, increased the efficiency and depth of ploughing. Furthermore, the tractor reduced the need for physical labour. As an underlying driver to the tractor purchase, food subsidies from the CCP left more income available for other investments and more time for off-farm activities; this generated more disposable income and created a situation where investment was possible.

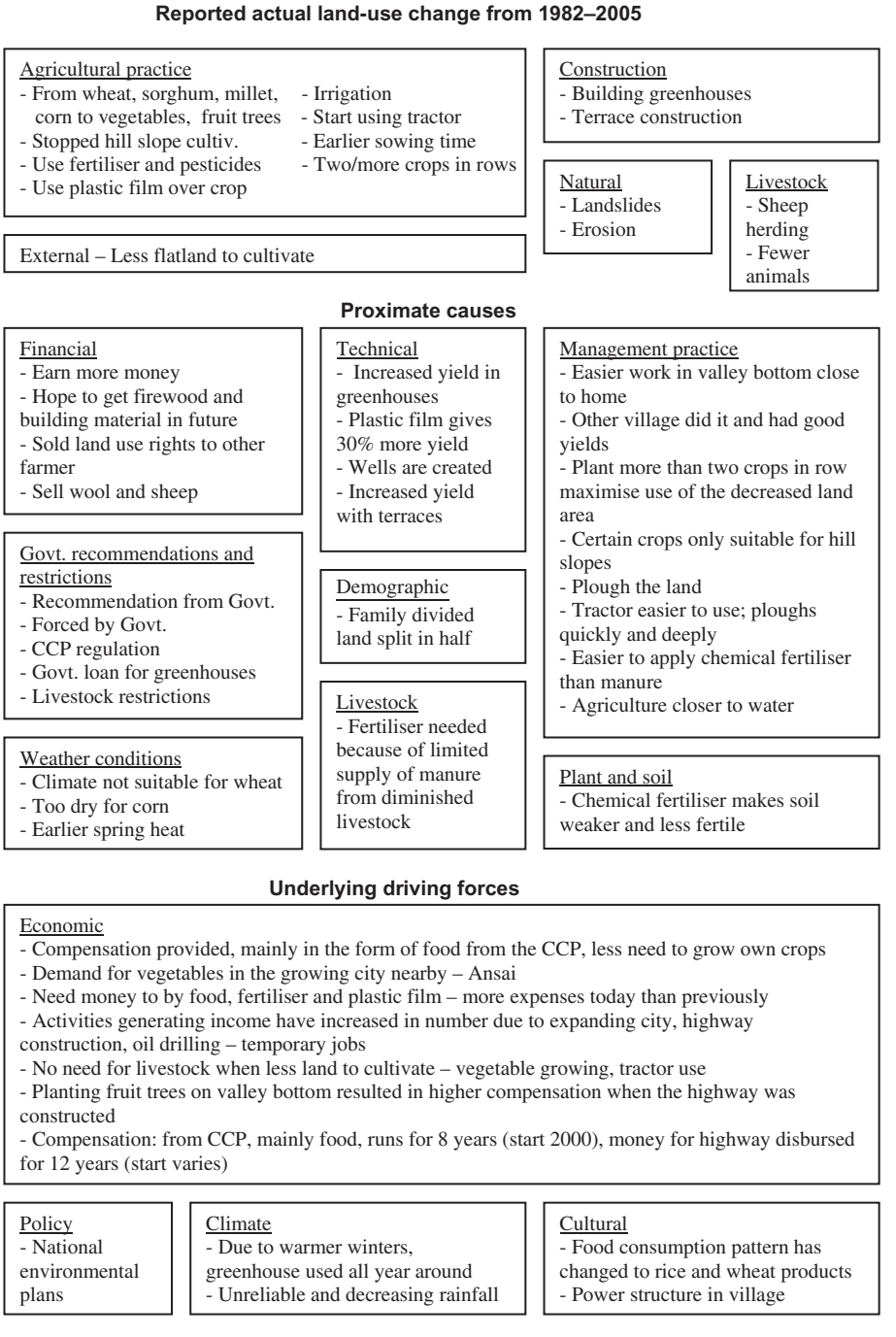

Figure 7. The land-use changes, proximate causes and underlying driving forces listed by farmers in the 23 structured interviews.

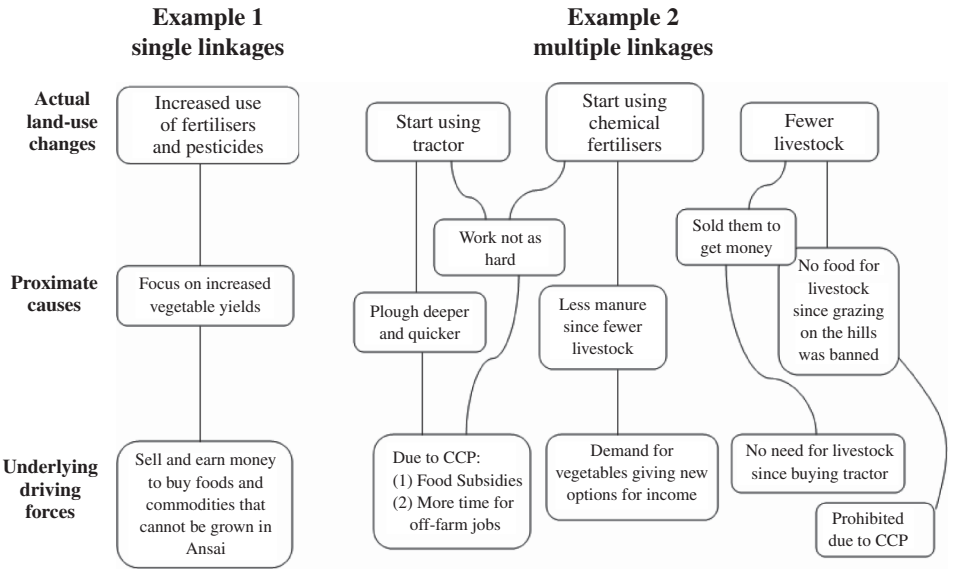

Figure 8. Two examples of reasoning by farmers in Ansai with regard to land-use change, proximate causes and underlying driving forces based on data from the structured interviews.

In addition, the demand for vegetables from a nearby city made the investment feasible. The introduction of chemical fertiliser was associated with two proximate causes: firstly, manure from livestock had become scarce because of the diminishing numbers of animals, and secondly, it was quicker and easier to apply chemical fertiliser to crops than to apply manure. The underlying driving force here was again the growing demand for vegetables, which was expected to provide a good income. The proximate cause behind the decreasing numbers of livestock was that there was no supply of natural fodder after grazing on hill slopes became illegal. Selling livestock also generated money for other investments. The underlying driving force here was that since the farmers had bought tractors there was no need for animals to support land management in the farming; although this had been the underlying driving force for selling the animals in this case, it could be regarded as a proximate cause for a particular land-use change. CCP, as a reform tool, was also stated as a driver since not grazing on the hills was a prerequisite for farmers to receive subsidies.

Discussion

The situation for small-scale farmers in the northern part of Shaanxi is characterised by a complex system of ongoing changes derived from natural processes such as climate variability, national environmental policies such as the CCP, and regional development processes such as urban sprawl and infrastructure construction.

Furthermore, according to the farmers in this study area, there is a greater variation in how to make a living today in comparison to the early 1980s, when individual farming restarted after the collective phase in China's agricultural history. They perceive themselves as being less vulnerable to natural changes such as climate variability, because they depend less on agriculture for their livelihood. A variety of technical and management introductions

such as irrigation, fertilisers, plastic film and greenhouses have reduced the exposure to the natural climate.

The dominant factor for the ongoing changes in the farmers' land-use decisions is the drive to earn more money. The present changes are making the farmers more dependent on money; furthermore, previous studies (e.g. Knutsson 2004) indicate that most farmers want to find different ways to make a living because farming in this area is hard work, has low productivity and has very low status. One assumption is that those farmers who have a chance to make a living from off-farm jobs will do so, whereas less well-off farmers have few alternatives other than to use their land to support their own livelihood.

The analysis suggests that the modified model can be used to find three important components in land-use change. Firstly, the actual land-use change, shown at the top of Figure 7, can be defined as the outcome or result of an action. Secondly, the proximate causes can be described as the tools, application or practices that farmers have used to achieve a goal that includes land-use change. Finally, underlying driving forces are, in the eyes of the farmers, only very indirectly linked to the change and lack practical meaning. This is exemplified by the climate variability (an underlying driving force) that farmers see more as a 'fate' than as an exposure that they can influence. Nevertheless, the sphere to focus on in terms of bringing about change is found in this last category or level, underlying driving forces, which can be seen as the engine for change, whereas the direct action taken by the farmer takes place at the proximate causes level. The differentiation between the proximate causes/tools and underlying driving forces/engines is highly relevant in terms of policy and aid implementations because the exclusion of either proximate causes or underlying driving forces can overlook the process involved in land-use change among small-scale farmers.

So what is the goal of these changes? The analysis suggests that farmers in this small-scale farming area are maximising the financial benefits that can be generated from the land that they tend, given the modalities that they are given in terms of rules and policies. This is illustrated by the crops they grow (Figure 6). The financial incentives for land-use change in this region are characterised by a short time horizon for future benefits. This is demonstrated by the references to the CCP as a time-limited policy that generates subsidies, as well as by the farmers' discussion regarding the use of fertiliser that is recognised as unsustainable, but yet still used. Hence, long-term economic benefits for farmers can drive sustainable land use in this region.

We have tested this model by applying it in a new setting, namely among small-scale farmers in a semi-arid environment. We find the model – in its modified version – to be a useful tool for understanding land-use changes on a micro-level. Furthermore, we argue that use of the model can be constructive before decision-making processes or policy implementation, because it provides insight into how large-scale changes influence changes in small-scale farmers' daily routines, as well as how a strong, indirect, underlying driving force can overshadow any attempts to bring about change at the proximate cause level. Nevertheless, more research is needed to understand the interrelationship between the proximate causes and the underlying driving forces. Relevant questions for further research could include: What happens when either a proximate cause or an underlying driving force changes? Will farmers change their land-use pattern if they are made aware of how underlying driving forces implicitly affect their daily work? How could the modified model be used practically among policy makers in terms of data input and scale?

Conclusion

- In an environment characterised by natural hardships such as erosion and water limitation, small-scale farmers perceive themselves to be less vulnerable today than they were 20–30 years ago because of their decreased dependence on natural factors such as rainfall and farm subsistence.
- The most dominating driver for land-use change perceived by farmers is economic and is described as earning money, and preferably more money.
- The modified model describes the array of actual causes, the proximate causes, as the tools that the farmers use, whereas the underlying driving forces are the engines of change. This level, however, is not practical for the farmers, hence all levels need to be assessed in policy-making situations.
- Short-term solutions for the farmers, in terms of land use, appear in the results. To generate more sustainable land use, long-term economic benefits for farmers should be sought in policy implementations.

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