Relations Key to Innovations – Peasants, Institutions and Technical Change on the Mossi Plateau in Burkina Faso

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Abstract

How should technical changes within food crop cultivation in a country like Burkina Faso be explained and understood? This is an important question for the reduction of poverty, for enhanced food security as well as for economic growth. In poor countries where agriculture is the dominating sector broad based economic growth requires increased productivity in food crop cultivation.

This study builds on fieldwork from three villages, undertaken in 2001/02 and in 2010. The villages are situated on the 'Mossi plateau' in the central parts of the country, where chronic poverty is most common, and where almost 80 percent of the households have experienced at least some episode of poverty during the period 2002-2007 (Wetta et al, 2010). The study concludes that the interplay between social institutions and new techniques, as well as the character of relations within the innovation system, are decisive in explaining the adoption of new techniques. Hence, established theories like the theory of induced innovation and the theory of innovation diffusion are unable to explain the findings from these villages. Instead, the innovation system theory is applicable, not least because the central role that power structures play for innovation.

Key words: Food crop productivity, innovation systems, Burkina Faso

1. Introduction

Recent policy changes in Burkina Faso, as in other sub-Saharan countries, include a move away from the predominant poverty reduction focus. Instead, inclusive economic growth comes to the forefront in an attempt to be more progressive. The major policy planning exercise nowadays concerns the "strategy for sustainable growth" (Palenfo, 2011). Oddly enough from a poverty reduction perspective, this has led to a renewed focus on productivity increases in agriculture, and in particular in small scale food crop production. Issues of how to bring about technical change are increasingly discussed. However, the understanding of such

processes remains limited. In this paper, we will put theories explaining technical change in agriculture to empirical test on the Mossi plateau of central Burkina Faso – an area where poverty and agro-ecological challenges remain very high, and where productivity increases in food crop production are needed the most.

2. Theoretical starting points

Technical change has been addressed intensively at the theoretical level. At least three major frameworks have been applied to explain technical change in peasant agriculture in poor countries: (i) The theory of induced innovation (Hicks, 1932, Fellner, 1961, Samuelson, 1965, Kennedy, 1966, 1967, Ahmad, 1966, Hayami and Ruttan, 1970, 1971, 1987, and Binswanger and Ruttan, 1978); (ii) The theory of innovation diffusion (Ryan and Gross, 1943, Rogers, 1962, Valente and Rogers, 1995); and (iii) The innovation systems approach (Carlsson et al, 2002, Sumberg, 2005, Lundvall, 2007).

According to the theory of induced innovation, the innovation process takes place as certain production factors become scarce, which in turn leads to a changes in relative factor prices. When this occurs, techniques that save on the scarce resource are promoted and implemented, be it land, labour or any other productive factor. The theory deals with rates as well as 'biases' in technical change, and it states that one specific factor experience greater proportional savings than others. According to this theory, innovation and technological adaptation of this character should be automatic and emerge in response to relative factor prices changes.[i]

But what if land markets and prices are missing? Dealing with such situations, Boserup argued that increasing population density is the active mechanism in bringing about technical

change (2008:20f). In a pioneering work she argued that it is the increased scarcity of land that drives the shortening of fallow periods, and induces more intensive farming in general. Such changes are preceded by periods of severely decreasing labour productivity, since the more intensive cultivation methods demand increased work efforts, which are resisted as long as possible. The situation Boserup described and analyzed was one of subsistence farming. Her argument has important similarities with the theory of induced innovation. Underlying both approaches is the assumption that scarcity and the human willingness to improve her situation are fundamental driving forces. Both approaches claim that the increasing scarcity of one factor of production leads to innovations that save on this scarce factor. What separate them are the mechanisms through which this change comes about.

The theory of innovation diffusion builds on the observation that innovations generally are not widely adopted when they first are identified – despite convincing advantages. Adoption rather forms S-shaped curves over time. At the heart of innovation diffusion is information and communication about the new idea. The theory distinguishes between different groups of adopters and focuses on their personal characteristics: innovators, opinion leaders, early adopters, late adopters and laggards. Innovators tend to travel and read widely and to have a cosmopolite orientation, but be weakly integrated in their local societies. Hence, information and advice on the innovation are more effectively conveyed to the majority by opinion leaders and change agents. The latter may be external actors – often professionals – that try to influence the practice in a local society in a particular direction. Change agents rely on the opinion leaders to help them in these processes (Rogers, 1962:23-28).

Innovation diffusion tends to take on a path dependent pattern. A social system, for instance a village, tends to adopt new techniques introduced by trusted opinion leaders and change agents. Once the adoption process takes off to reach early and late adopters, one particular

technique tends to dominate in that particular village or social system. Such technical change may, or may not, save on the scarce production factor. Factors scarcity is not the reason for its spread. Techniques are rather adopted as a result of a communication process, which is conditioned by the characteristics of the involved actors.

The innovation system approach refers to 'system' as "a set of interrelated components working toward a common objective" (Carlsson et al, 2002:234). Central entities in an innovation system are actors, relations between these actors and institutions. The approach is in many ways compatible with the previous. Improved feedback between the components makes the innovation system more dynamic, and more able to generate, diffuse and utilize techniques (Sumberg, 2005:24). Whereas the communication process, and thereby relations, drives technical change according to the innovation diffusion model, it is the combination of actors and the wider institutional context that is in focus in the innovation system model. In particular, the interplay between institutions and the new technique is central. The innovation system may be described as a neo-Schumpeterian approach (Spielman 2005:8f, 17, 43).

The reason why indigenous institutions may be important for technical change in sub-Saharan peasant agriculture is that they coordinate particular collective action problems. The combination of scarce resources, a risky production and market environment and complex social learning conditions creates a demand for institutional solutions. Institutions that have managed to address such problems over time are sticky because of their proven ability (de Laiglesia, 2006). Such stickiness also translates into path dependency in the area of technical choice.

Despite multiple theoretical approaches, empirical tests in sub-Saharan Africa have been sparse, except for Carter (1997, 2008) and Goldman (1993). They arrive at the same general

conclusion that the theory of induced innovation cannot explain technical change in peasant agriculture in sub-Saharan Africa. However, they do not provide alternative explanations or theoretical frameworks.

This study takes this theoretical discussion as a starting point. The hypothesis is that important elements can be applied from all three theoretical approaches. More specifically, it is assumed that technical change is driven by scarcity and human willingness to change (induced innovation); that it is shaped by the character of communication between various actors (innovation diffusion), and conditioned by the interplay between institutions and new techniques (innovation system). On this basis we move on to study dynamics of technical change in selected villages in Burkina Faso. The purpose is to describe the dynamics of technical change, and assess to what extent such dynamics can be understood in an innovation perspective.

3. Choice of study areas

This study is based on fieldwork in three villages on the central, 'Mossi', plateau of Burkina Faso. The plateau is mainly inhabited by people from the largest ethnic minority in the country, the Mossis. However, other ethnicities live all over the area, and co-habituate with the Mossis in each village. There is a hierarchy in the villages based on settler arrival. The original inhabitants have rights to cultivate the land based on inheritance. The chief system is also linked to this ethnic structure, and the chiefs are entrusted with the right to distribute lands to those that request it, including newcomers who wish to settle in the village.

The Mossi plateau is characterized by a high level of poverty. Almost all of the provinces in Burkina Faso with high concentration of chronic poverty are situated on the Mossi plateau

(Wetta et al. 2010: 31). Most plateau dwellers are actively engaged in agriculture. The agro-ecological conditions for cultivation are harsh, with degraded soils, low and increasingly erratic levels of rainfall (between 600 – 900 mm per year), and limited access to water for large parts of the year (INSD, 1996:5-12). The population pressure is high and increasing given the agro-ecological conditions. On average, Burkina Faso has a population pressure above 100 inhabitants per square kilometre, with the highest on the central plateau (Wetta et al, 2010:32). With estimations based on food production, and a poverty threshold defined as 190 kg food produced per person and year, almost 80 percent of households surveyed had experienced at least one incidence of poverty between 2002 and 2007. In other words, the food production system is so risky that very few can be sure of escaping incidences of poverty (Ibid, p. 37). Lachaud (2005: 239) classified almost 52 percent of all households in Burkina Faso as vulnerable to poverty in 1998.[ii] It is highly likely that this share is above average on the Mossi plateau, given its high rate of chronic poverty.

A productivity increase in staple food crop cultivation would have the largest potential effects on poverty reduction on the Mossi plateau. Another reason for selecting the Mossi plateau as an area of study are indications that income diversification is relatively lower there compared to other areas where agriculture is widespread (Reardon et al 1992:264-295).

3.1. Description of villages

The three villages studied are Gandaogo, Rapogouma and Mané. The first two were visited after the cultivation seasons of 2001 as well as in November 2010. Gandaogo is the southernmost of these villages, situated in the central-east province of Ganzourgho, some 70 kilometers east of the capital Ouagadougou. Mané is situated 80 kilometres north of the

capital, in the province Sanmantenga. Rapougouma is situated some 180 kilometres north, north-west of Ouagadougou in the province of Oubritenga. All three villages are reasonably well connected to urban areas and markets, with distances varying between 10 to 20 kilometres, along dirt roads. Road conditions are worst for Gandaogo, to which car access is difficult. Motorcycle or bicycle works fairly well, though.

Mané is somewhat larger than the two other villages, and it is hosting a police station, a municipal office and an agricultural extension service office. Also farmer associations have offices here. This makes the role of customary chiefs different compared to the smaller villages, with secular officials are competing with the chief over influence. The local market is also more developed and the village has more urban elements, such as a grocery store, small cafés and huts/ houses that are let out through a renting system. The latter practice implies some first possible steps towards an emerging land market for settlements. Some urban land planning is emerging and on certain plots rudimentary houses are being built, in order to make future claims to these lands.

In Muslim dominated Rapogouma household sizes are generally bigger, and homesteads organized in quarters rather than in the more dispersed way that is found in Gandaogo and Mané. The geographical location towards the north of the country implies that Rapougouma is experiencing more soil degradation, decreasing or erratic rain and high temperatures than the other two villages.

All three villages have similar patterns of household organization. An average household is led by a household head, usually a man, who may have wife(s), younger brothers with wife(s), as well as children and elderly people with limited capacity working. The household head is responsible for cereal cultivation on the family field/s, usually red and white sorghum and

millet, intercropped with beans. All other capable household members are supposed to contribute work to these household fields. When cultivation on household fields is finished, women and younger brothers cultivate their own separate field/s. Women should cultivate crops for making the 'sauce' that go with the meal of cereals. Thus, women have a clearly defined role in the household economy, as have the household head. Once the 'sauce' crops are assured, cultivation with the purpose of selling may be undertaken. Women often cultivate peanuts, or pluck shea nuts for processing and sale. The incomes are controlled by the women, which, however are expected to pay for a number of household related expenses. The household head and other men also cultivate cash crops, for instance cotton or tobacco. The men are also charged with household related expenses, but of other kinds.

Animals rearing (cows) is the main responsibility of men, while smaller animals such as sheep, goats and chicken rather are the responsibility of women.

This division of household tasks leaves the younger men as the economically most independent group. With norms undergoing change, they are increasingly free to use their possible earnings for their own consumption. The youth has historically been involved in labour migration. This has either been for longer periods working in neighbouring countries, or during the dry season of the year. The objective of such migration has been to accumulate funds in order to establish a new household. Lately, the practice of gold digging or gold mining has become increasingly common within this group, replacing the work in agricultural plantations in coastal countries. Older men may eventually also take part in gold digging. However, the majority of gold diggers are young men between 16 and 30 years. One result of the increasing economic independence of young men is the increased prevalence of mopeds and motor cycles, along with mobile phones, in rural areas. It is nowadays not uncommon to see motor cycles worth of 2000 US dollars outside an ordinary rural hut.[iii]

4. Technical change in various areas

4.1. Adoption of improved seed varieties

Given the centrality of cereal cultivation for household food security and economy, the use of improved seeds of staple crops like sorghum is key. With decreasing and more erratic rain, crop drought resistance and shorter maturation becomes even more important.

We note from table 1 that the use of improved seed have decreased slightly in the sample villages, while use of chemical fertilizer have increased slightly. Since samples are small (n=90 in sample), trends are not the most interesting, but rather the understanding of the behaviour behind the choice of techniques.

[Table 1 about here]

New seed varieties are almost exclusively distributed through the extension system. Through this, small portions of new seeds are sold at a subsidized price, and the distribution is undertaken through official channels. For Gandaogo, the distribution comes through an extension office in the nearby village Zongho. This often implies time delays, which lead many peasants abstain from new varieties since they have already finished sowing. In Rapogouma and Mané distribution is more efficient, because of shorter distances to distribution centres. In the three villages, no single case was observed of households buying new seed varieties with the intention of saving until next cultivation season.

When new seed varieties are distributed to the village, the local government representative, the ‘delegué’ – who in Gandaogo is also a village chief – is in charge. He calls on households to come and pick up the new varieties. Since the amount of seeds available is sufficient for only about 20 households, he tends to call on those that he believes are willing and capable to

take on new varieties. Hence a judgment by the chief/delegué becomes part of the diffusion process.

Following the theory of innovation diffusion (Rogers, 1995) the interviewed population can be categorized into three major groups: the early adopters of new varieties, the late adopters and the non-adopters. The first category is the smallest, comprising only some five percent of the households in the sample. This category tends to acquire new seed varieties from the extension services at an early stage. Furthermore, during the growing season, these people move around and study varieties grown by peasants in nearby villages. When the harvest season arrives it is common for them to go back to peasants that have grown promising varieties and ask for some seeds. These are then saved for the next growing season.

As predicted by the theory of innovation diffusion, this group of peasants show entrepreneurial characteristics. They seek information and are actively interested in finding new and more promising varieties. They use other channels to obtain new seed varieties than the official ones: they buy seeds on the market, or they search out other farmers in order to ask for a share of their seeds. However, only a small part of all peasants belongs to this group.

Only one out of the 25 households interviewed in Gandaogo can be classified as 'early adopters'. The total share of households that use new seed varieties constitutes one third of the interviewed sample. In Rapogouma the use of new varieties is somewhat more widespread, comprising 40 percent of interviewed households. Due to more erratic rains in this northern village, the need for rapidly maturing varieties is even more pronounced. Out of these, only three households (12 percent) may be placed in the 'early adopter' category. The non-adopters are a majority also in this village. Hence, even in this village, where the need for

taking on new and faster maturing seed varieties is seen and broadly acknowledged, a majority continues to cultivate the old varieties.

The village of Mané provides an interesting variation. Almost three out of four households in this village use the new, rapidly maturing, seed varieties. A clear majority has taken on the cultivation of new seeds. Even here, households that are searching out new varieties on their own, and experimenting with the new seeds ('early adopters') are only one or possibly two. What can be the possible reason for the 'late adopter' group to grow so large in Mané, when this did not happen in Rapogouma or Gandaogo?

The quality of soils and rainfall is lower and more erratic in Rapogouma. Furthermore, the cultivated land per inhabitant is the lowest in Rapogouma (0,31 field/person), with Mané taking on a middle position (0,38 field/person, Gandaogo 0,47 field/person). None of these variables are correlated with the higher use of improved seeds in Mané. Hence, the explanation must be sought elsewhere. A plausible reason is that the agricultural extension service has an office in Mané and most people have been in direct contact with the extension workers. People know that they may find new seed varieties with extension workers. There is as well a marked difference in knowledge about seed varieties because of this presence.

This interpretation is reinforced by a parallel analysis of the drivers of adoption of improved seed varieties in the full sample, using households – not villages – as the analytical unit. An OLS regression with adoption of improved varieties as the dependent variable indicates that only group membership and a dummy variable for the Mané village are statistically significant. Various household characteristics, the area cultivated, the number of available labour force are factors that are not correlated with the adoption of improved varieties in this three village sample. The Mané dummy variable remains significant even after testing for

group membership. This implies that some other characteristic of this village must be decisive – a reinforcement of our argument that the presence of the extension office in that village is important.

This finding is reinforcing results obtained by Adesina and Badu-Forson (1995) who found participation in on-farm test significantly related to the adoption of modern sorghum varieties, which underlines the importance of a functioning extension system.

As to the non-adopters, the most common argument used by those who do not cultivate new seed varieties is that they claim not to know where to get information on where to find new varieties. However, many admit that they actually have received information about such varieties.

Household heads that have heard about, but still chose not to use, the new varieties come up with a number of arguments to rationalise their decision. What seem to be major reasons relate to the taste of the food, and lack of knowledge on how to cultivate the new varieties. Very few cases were registered where the peasant claimed to have made field test and then abandoned the new variety due to the result of actual trials.

4.2. Chemical fertilizer use

Even though chemical fertilizer represents a well-known technique, it is still relevant in this context. It may be seen as part of a technology package together with improved seeds. The restudy of villages show that awareness of the importance of chemical fertilizer has increased. This was particularly so in Rapogouma that has been more exposed to soil degradation, erratic and decreasing rain levels. The dynamics for getting hold of, and utilising fertilizer, differ between villages. In Rapogouma fertilizer is bought in the market, and usually applied

through the ‘micro dose’ method. This means that fertilizer is only spread directly on the plant, when the first rains have come.

In Gandaogo, where the use of chemical fertilizer is highest it is the cultivation of cotton that provides the main channel for access. Cotton cultivators are required to organize in groups, which sign contracts with the cotton company SOFITEX. Seeds and fertilizers are distributed on credit by SOFITEX. These costs are deducted from the incomes of groups at the time of harvest. How much fertilizer to apply is decided by a representative of the company, after measuring the cultivation plot. Fertilizer is applied on the entire plot.

Cultivators subsequently grow cotton on a particular field one year, but shift to other fields in following years. This enables the same plot to benefit from the fertilizers also next year when a food crop is cultivated. In this way cotton cultivation is used as an indirect way of enriching soils. Many cultivators continue with cotton even though they make little or no profit from it.

When the total sample was analysed with households as the analytical unit the only factors that showed a statistically significant correlation with fertilizer use were found in the 2000/01 sample and included a Gandaogo dummy, access to credits and the availability of other incomes. Since agreements with SOFITEX include credits, and since Gandaogo was the cotton cultivation par preference that period, this is another way of stating the importance of cotton cultivation to access chemical fertilizers. In the 2010 sample there was correlation between use of chemical fertilizer and the surface cultivated per labourer in the household. But the cultivated surface was also correlated with use of plough. It might be that the use of plough has opened up possibilities to cultivate larger areas per person, which in turn might have increased affordability of fertilizers.

4.3. Plough use

Another technical change concerns the adoption of the plough. The plough replaces the hoe and enables the cultivation of larger fields with the same or less amount of labour input. The plough may either be drawn by donkey or by oxen. The function of these two different types of ploughing is similar; it is rather a matter of what animal is available to do the pulling. Table 2 indicate that there has not been any major shift in plough use in these villages, even though the national average has increased from 32 percent in the mid-1990s to slightly above 50 percent ten years later (MoA, annual statistics). The use of the plough is highest in Mané (76 percent), followed by Gandaogo (60 percent) and Rapogouma (37 percent). This is somewhat unexpected since, analyzed on the village level, the use of plough is not correlated with the average cultivated area per capita (Gandaogo, 0,47 ha/pers; Mané 0,38 ha/pers; Rapogouma 0,31 ha/pers). Neither is it correlated to the quality of soils, nor the level of rainfall (lowest in Rapogouma, higher in Mané and Gandaogo). Hence, even in this area there seems to be some other factor that explains the use of ploughs.

Is the adoption of the plough in any way connected to the evolution of household size? On this point comparison with the Mané village is less helpful, since that village did not appear in the 2001/02 sample. However, the evolution of household sizes may be studied in Gandaogo and Rapougouma. Comparisons between these two villages indicate that average household sizes have decreased over the last years. In Rapogouma it decreased from 18,8 household members to 17,0, and in Gandaogo from 14,6 members to 11,9. In Mané average household size was 13,8 members in 2010.

[Table 2 about here]

A decrease in average household sizes was as well observed when comparing the full sample of 2001/02 with that of 2010. However, the villages included in these two samples are not the

same and the comparison suffers from substantially different average household sizes between villages. Hence, this comparison illustrates a general reduction in average household sizes during the last ten years.

The decrease in average household size and the simultaneous population increase imply that more household units exist today, as compared to ten years ago. This contributes to increased land scarcity and an increased use of marginal lands for cultivation and grazing. Is there a connection between the use of plough, increased population size and decreasing sizes of households? Seen at the aggregated level of villages, the average size of households as such is not correlated with the use of ploughs, since Mané has the largest level of plough use, but only the second lowest household sizes. However, an analysis of the full three-village sample, with households as the analytical unit, shows that a weak correlation between the cultivated area per labourer and the use of the plough cannot be rejected. This correlation appears in the 2010 sample, but not in 2000/01. Furthermore, the causal direction is not clear. Is it the cultivation of larger areas that lead people to take on the plough, or is it the use of plough allows households to cultivate larger areas? What may be concluded is that the change in household sizes is taking place in parallel with the increased use of ploughs, and that changes in household size have institutional dimensions, since it would affect intra-household labour division, as well as the distribution of responsibilities.

There is a statistically significant correlation between the use of plough and a dummy variable for the Mané village in the 2010 sample (refer Annex 1). In the 2000/01 sample, there was likewise a statistically significant correlation with a dummy variable for Gandaogo.[iv] One factor that was observed in Mané 2010 is that the majority of those using ploughs have obtained them through a (externally financed) credit scheme run by a peasant association called ADRK (Association pour le Développement de la Région de Kaya). A very small

minority claim to have started using ploughs before they were offered the opportunity to buy them through ADRK. An indicator that ADRK in fact is the major supplier of ploughs is that most ploughs in use are of the donkey type. In the credit package offered by ADRK donkeys are included. It seems that it is the presence of this peasant association that has provided an increased possibility for peasants to acquire ploughs.

In Gandaogo in 2000/01 there were many peasants that were members of associations and groups. There had also been externally financed programmes to spread ploughs. The NGO 6S (Se Servir de la Saison Sèche en Savane et au Sahel) had been actively distributing ploughs for 15 years but stopped doing that in 1997. In Rapogouma no similar intervention had occurred.

The pattern that emerges is that ploughs have been introduced in some of the villages with the help of external financial support, and through regional peasant associations such as ADRK or 6S. When ploughs have been introduced, they have enabled peasants to cultivate larger areas. This conclusion can be drawn since the correlation between the use of plough and area cultivated per labourer emerged in the 2010 sample, but not in the 2000/01 sample. Hence, the direction of the causal relation is such that increased use of the plough leads to cultivation of larger areas per person.

4.4. Techniques for restoring soils and saving water

Techniques for soil and water conservation (SWC) arrived in the villages through the activities of peasant associations working in tandem with external change agents. The trend started in the early 1980s, as a reaction to widespread famines. They were in turn a consequence of decreasing levels of rain in the western parts of the Sahel from the late 1960s

onwards (Botoni and Reij, 2009:9). On the Mossi plateau, three techniques have dominated. One is the building of stone walls for levelling the slope of the ground, and hence slowing down the flow of rainwater, increasing infiltratation. The second is called 'zaï' and consists of digging 15-20 cm deep holes for the sowing of crops with a pile of soil resting on the downward sloping side of the hole. When the crops are sown, compost is added to the hole. The third technique is mulching, where compost is gathered and processed in order to be spread over fields when the rainy season starts (Slingerland and Stork, 2000). Thanks to the combined use of different SWC techniques it is estimated that about 300 000 hectares of land have been restored during the last 25 years on the Mossi plateau (Botoni and Reij, 2009).

The zaï technique is traditional, but was readopted by a peasant and innovator in the Yatenga province, Yacouba Sawadogo, in the early 1980s. The results of his experimentation have been diffused with the help of farmer associations and NGOs, often financially supported from abroad. A central role was also played by another Yatenga peasant, Oussein Zorome, who set up a 'zaï school' and organized an association, which now has about 1000 members. This association is running extension services (Kaboré and Reij, 2004). The diffusion of these SWC techniques has been described as following the pattern of innovation diffusion (Ibid: 4ff). It should in this context also be noted that a common theme for these associations has been references to traditions and indigenous practices (Lédea Ouedraogo, 1990). A spatial difference in terms of popularity between the different techniques has been observed, but remains mainly unexplained (Slingerland and Stork, 2000). Such a difference was also noted between the villages in this study, with zaï more common in Rapougoma (74 percent), followed by Mané (45 percent) while composting was the only of the two techniques used in Gandaogo (25 percent). This distribution remained relatively unchanged over the ten year period studied.

A correlation between household size and the practice of zaï has been observed in some studies (Slingerland and Stork, 2000: 72, Sidibé, 2004), but was not found in these villages. However, the practice of zai is labour demanding with estimations of about 300 man-hours per hectare of cultivated land needed. A mechanized version of the zaï, which is much less labour intensive (40 man-hours per hectare), has been introduced in the area but has so far remained very sparsely diffused. This is peculiar, since the general use of the plough is rather widely spread. A possible reason might be that zaï normally is the work of women, whereas ploughing is done by men. The introduction of the mechanized version of the zaï would imply changes in the gendered division of labour, to which there is resistance. The reason provided by Clavel et al (2008) is in line with this. They argue that the mechanised version of zaï has not been properly integrated in a process where economic, social and ecologic sustainability can be assured (Clavel et al., 2008:9). In particular, it is the lack of interplay between the technique and societal processes that they underline in their explanation.

5. Discussion

Major tendencies in these three villages over the last ten years have been stability in the use of fertilizers, improved seed varieties, soil and water saving techniques and in the use of ploughs. The spread of these techniques have been slow. The use of techniques has also showed clear patterns of path dependency, with types of techniques differing between villages. When factor bias of technical change is considered especially the labour saving increased use of ploughs, and the associated extension of land cultivated, stand out as an anomaly in relation to an increasing scarcity of land. The theory of induced innovation is not able to explain this. Neither is Boserup's thesis of a period of decreasing labour productivity preceding the introduction of land saving innovations very relevant in this situation.

Much in line with alternative theoretical approaches, we conclude that outside actors and structures play decisive roles in the diffusion of different agricultural techniques in the villages studied. In the case of new seed varieties, there is one dominant channel through which they spread – the state's agricultural extension service. There is furthermore an interplay and collaboration between the state structure and the customary chief system that makes this distribution channel more hierarchic. It is very rare to access new seed varieties outside of these hierarchical channels – even if possibilities exist. The role of 'opinion leaders' in these villages is fulfilled by the chiefs. It is noteworthy that the chiefs often simultaneously fulfil the function of local state representatives, the 'délegués'. If these individuals are open to technical change, they may play an active role in the proliferation of new seeds. If they are reluctant, they may become important obstacles to innovations.

Even though certain practices in the three studied villages lend support to the theory of innovation diffusion there are important misfits. The particularity that 'opinion leaders' simultaneously fulfil roles in the actual distribution chain and take practical decisions that affect the diffusion of new techniques is perhaps the most important. The selection of households eligible for seed distribution in the first round is such a decision, where preferences of the chief/ 'délegué' will affect the decision. The power of the chief and of prevailing hierarchical structures is reinforced (Author, 2004a:159). This finding is in line with the innovation systems approach, in which the character of relations between actors and institutions are given central importance.

The diffusion of ploughs has occurred through the supposedly more independent channel of peasant organizations. Has this contributed to break up hierarchical structures? Has a higher level of collective organization opened opportunities for technical change?

The interviews show a higher share of group membership in Gandaogo as compared to the other two villages. But this does not translate into plough use, which is highest in Mané, with Gandaogo only in second place.

A plausible reason behind the higher membership rate in Gandaogo is that cotton cultivation requires a prior formation of groups. Seeds and fertilizer are obtained on credit from the cotton company SOFITEX, and such credit is only given to groups. Hence, group membership is mandatory for cotton cultivators. Of the three villages in the sample, cotton is only cultivated in Gandaogo. This explains why organizational membership may be higher there, despite similar levels of willingness to organize. It is also evident from interviews that a major reason why peasants in Gandaogo cultivate cotton is that they access fertilizers that way. The importance of centralized structures and channels for the diffusion of techniques stands out clearly. A qualitative assessment based on interviews and observations shows as well that the willingness to take on collective activities might be roughly equal between the villages.

Despite being alternative channels, peasant organizations are in fact seldom less hierarchical than the official system. Cases are legion of organizations that are controlled and run by single individuals, who often belong to, or emanate from, the chief system. With this, a system of redistribution from a central node to subordinated subjects may be observed even here, as well as in the official system (Author, 2004b). There are clear similarities to the official hierarchically structured extension system. The role of the ‘opinion leader’ is still combined with the role of decision maker. Distribution and access to chemical fertilizer is a parallel case to that of ploughs where a hierarchical structure shapes the conditions for access.

Through the lens of the innovation diffusion approach, the official extension system and farmer associations would be 'change agents', introducing new concepts, ideas and worldviews. However, this is not the case. In at least two of the three villages, these external actors become parts of a hierarchical structure that control the distribution of material resources. A power dimension is added to the diffusion process, which contribute to a bias in terms of who can access the resources. It is not only the character of the agents that influences the diffusion process, but also their relative strength in relation to other agents.

The increased level of organization provides a larger number of channels and opportunities for the diffusion of ploughs. These channels would provide an increased use of ploughs. However, they would not provide a system with multiple interrelations that would allow for innovations in a broader sense to spread. There is an important difference between channels for the diffusion of known techniques and channels for the spread of innovations. The latter would be characterised by interchange and mutuality to a much larger extent. While the former system would answer the demand for more ploughs, the latter would respond to the need for new and more efficient ways of preparing the soil for cultivation.

The correlation found between the use of improved seeds and group membership may be interpreted in different ways. It may be that increased willingness to organize goes together with increased openness to take on new things. The only problem is that this would have implied a correlation also between group membership and the use of plough – which was not observed. It may alternatively be a matter of mutual learning taking place within groups, which enables the use of new seed varieties. This argument can be refuted with the same argument.

A more plausible explanation is that group membership is a way of dealing with the hierarchical system and forging relations with the person that undertakes the initial deliveries of new seeds or ploughs. The presence of associations such as ADRK or 6S makes for a higher use of ploughs. A high general willingness to organise was present in villages where ploughs were used more widely. Nevertheless, most of the ploughs had already been distributed in the villages at the time of fieldwork. Peasants did not feel the need for continued membership in these associations when they already had acquired ploughs. This may also explain why a significant correlation between group membership and plough use was not found at household level.

In sum, what has been most decisive for the adoption of improved seed varieties, ploughs, fertilizers, and arguably also for SWC techniques has been the character of relations between actors involved in the distribution and diffusion of these techniques. This is a finding in line with the innovation systems theory. The presence of important actors in the village led to higher adoption rates of ploughs and seeds in Mané, since relations between them and peasants were more intense. The presence of a particular kind of distribution channel, through SOFITEX, led to higher use of fertilizer in Gandaogo.

A further inference is that diffusion of new techniques to large extents hinges on simultaneous changes or transformations in indigenous institutions. Techniques that have been most easily diffused are SWC techniques. These have built on traditional practices, and have fitted established norms for gendered labour division. However, varieties of such techniques, which demand alterations in intra-household labour divisions, have faced difficulties in spreading.

The importance of simultaneous institutional change was shown also in other areas. For instance, the widespread use of ploughs has emerged when changes in household sizes have

been underway. Such changes are likely to have institutional repercussions, which may have enabled the adoption of this technique. Smaller household units would rather cultivate more extensively, using the plough.

In the studied villages path dependency is prevalent in the use of techniques. Clear differences were observed between the villages regarding SWC and fertilizing techniques that were used. The prevalence of zaï, fertilizer micro dosing and composting depend differ between villages. In addition, both the use of plough and the adoption of improved seeds depend in a statistically significant way on which village one lives in. There are issues of path dependency to consider in all these processes.

6. Theoretical implications and conclusions

Several conclusions may be drawn from this study. The theory of induced innovation is not able to explain the labour saving bias of the rapid spread of ploughs in areas with increasing land scarcity. It is also unable to explain the observed path dependency of technical change. This takes the form of different SWC and fertilizing techniques dominating in different villages, and of specific village characteristics explaining the pace of introduction of improved seeds as well as ploughs.

Differences in the way ploughs as compared to improved seeds are adopted show that even the theory of innovation diffusion has difficulties in explaining agricultural technical change in these villages. It is not the inner characteristics of people that are most influential cause – even if such differences exist and lead to the expected structure of diffusion, with early and late adopters. It is rather the character of relationships, and power structures, within the system for accessing new technologies that decide how the diffusion unfolds. The distribution

channels for improved seed varieties are more centralized and hierarchical than ploughs. This has led to improved seeds being spread slower than ploughs, and also following a different geographical pattern.

The most centralized system for accessing productive technologies is perhaps the channels for fertilizers, particularly in one village, Gandaogo. Here the diffusion comes through a prior entry into cotton cultivation.

The approach that best explains agricultural technical change in the three villages is the innovation systems approach. It allows for an analysis of how relationships are structured, and for including the role of power relations. In addition, it also allows for an analysis of institutional aspects, which is mainly overlooked in the other approaches.

What we observed in the villages as a factor affecting technical diffusion is the interplay between prevailing institutions and new techniques. For instance, in the case of ploughs new and smaller household units are emerging. In the case of fertilizer, especially in Gandaogo, the role of the household head is reinforced, since access to this input comes through a channel controlled by the household head: the cultivation of cash crops such as cotton.

The spread of SWC techniques depends to some degree on already established norms and patterns for intra-household labour divisions. Versions of the technique that would demand alterations of intra-household labour divisions have had difficulties to spread, despite their potential of providing higher yields and decrease in labour demand.

It would be easy to interpret difficulties of access to various productive factors and technologies as a matter of lacking resources. This interpretation is especially tempting in a very poor country, such as Burkina Faso. But it would be too simplistic to explain poverty with poverty. The interplay between local power structure and centralized systems for

redistribution that we have dwelled on is a more relevant factor, shaping entitlements. The understanding of how indigenous institutions and local power structures interplay with new techniques adds to the description of how techniques get diffused. By applying the innovation systems approach, we realize that both the character of relationships and institutional structures need to be analysed alongside the pattern of communication around new techniques. Without such a wider approach, technical change in peasant agriculture on the Mossi plateau in Burkina Faso cannot be properly explained.

References

Adesina, A.A. and J. Baidu-Forson, (1995): "Farmers' perceptions and adoption of new agricultural technology: evidence from analysis in Burkina Faso and Guinea, West Africa", *Agricultural Economics*, Vol 13, pp 1-9.

Ahmad, S., (1966): "On the Theory of Induced Investment", *The Economic Journal*, LXXVI (June 1966), 344-357.

Author, (2004a): *xxxx*

Author, (2004b): xxxx

Binswanger, H. and V.W. Ruttan, (1978): *Induced Innovation: Technology, Institutions and Development*, Johns Hopkins University Press, Baltimore.

Boserup, E., 2008 (1965): *The Conditions of Agricultural Growth – The Economics of Agrarian Change under Population Pressure*, Aldine Transaction, New Brunswick, USA and London, UK.

Botoni, E. and C. Reij, (2009): "La transformation silencieuse de l'environnement et des systèmes de production au Sahel : Impact des investissements publics et privés dans la gestion des ressources naturelles », *Centre for International Cooperation*, the Free University, Amsterdam, the Netherlands.

Carter, M.R., (2008): "Inducing Innovation: Risk Instruments for Solving the Conundrum of Rural Finance", Paper presented at 6th AFD/EUDN Conference, Paris.

- , (1997): "Environment, Technology, and the Social Articulation of Risk in West African Agriculture", *Economic Development and Cultural Change*, pp 557-590

Clavel, D., A. Barro, T. Belay, R. Lamar and F. Maraux, (2008): "Changements techniques et dynamique d'innovation agricole en Afrique Sahelienne: le cas du Zaï mécanisé au Burkina Faso et de l'introduction d'une cactée en Ethiopie », *VertigO*, Vol 18 :3, pp 1-10.

Fellner, W., (1971): "Empirical Support for the Theory of Induced Innovation", *Quarterly Journal of Economics*, Vol. LXXXV, pp 580-604.

INSD (1996): "Annuaires series longues du Burkina Faso", Institute National de la Statistique et de la Démographie, Gouvernement du Burkina Faso, Ouagadougou.

Goldman, A., (1993): "Agricultural Innovation in Three Areas of Kenya: Neo-Boserupian Theories and Regional Characterization", *Economic Geography*, 69,1: 44-71

Hayami, Y. and V.W. Ruttan, (1970): "Agricultural Productivity: Differences Among Countries", *American Economic Review*, Vol 60, No 5: 895-911

- (1971): *Agricultural Development: An International Perspective*, Johns Hopkins University Press, Baltimore

- (1987): "Population Growth and Agricultural Productivity" in Johnson, D.G and R.D. Lee (eds) *Population Growth and Economic Development: Issues and Evidence*, University of Wisconsin Press, Madison.

Kaboré, D. and C. Reij, (2004):"The Emergence and Spreading of an Improved Traditional Soil and Water Conservation Practice in Burkina Faso", *EPTD Discussion Paper* No 114, IFPRI, Washington D.C.

Kennedy, C., (1964): "Induced Bias in Innovation and the Theory of Distribution", *The Economic Journal*, LXXIV (Sept 1964), 541-547.

- , (1966): "Samuelson on Induced Innovation", *Review of Economics and Statistics*, XLVII (Nov 1966), 442-444.

Lachaud, J-P., (2005): "A la recherché de l'insaisissable dynamique de pauvreté au Burkina Faso. Une nouvelle evidence empirique", Document de travail 117, Centre d'économie du développement, IFREDE-GRES, Université-Bordeaux IV.

de Laiglesia, J.R., (2006) : "Institutional Bottlenecks for Agricultural Development - A Stock-Taking Exercise Based on Evidence from sub-Saharan Africa", WP No 248, OECD Development Centre, Paris.

Ministère de l'Agriculture, de l'Hydralique et des ressources Halieutiques (plusieurs années) : "Enquête permanente agricole", Direction Générale des Prévisions et des Statistiques Agricoles, Ouagadougou, Burkina Faso.

Palenfo, Philippe, Direction de la coopération décentralisée du Ministère de l'Économie et des Finances, personal communication, February 2011.

Reardon, T., C. Delgado and P. Matlon, (1992): "Determinants and Effects of Income Diversification amongst Farm Households in Burkina Faso", *Journal of Development Studies*, Vol 28, No 2, pp 264-295.

Rogers, E. M. (1995): *Diffusion of Innovations* (4th Edition), The Free Press, New York City, NY.

Slingerland, M.A. and V.E. Stork, (2000): "Determinants of the Practice of Zaï and Mulching in North Burkina Faso", *Journal of Sustainable Agriculture*, Vol 16:2, pp 53-76.

Valente, T.W. and E.M. Rogers, (1995): "The Origins and Development of the Diffusion of Innovations Paradigm as an Example of Scientific Growth", *Science Communication*, Vol 16, No 3:242-273.

Wetta, C., S.T. Kaboré, L. Kibora, A. Nikèma, M. Kone, M. Kondé, M-E. Malgoubri, P.M.F. Zida, A. Sawadogo and H. Ouedraogo, (2010): "Pauvreté Chronique et Transitoire au Burkina Faso: Une analyse de la dynamique à partir de donnés agricoles", *(mimeo) Projet de Recherche sur la pauvreté chronique, CEDRES/ Chronic Poverty Research Centre*, Ouagadougou, Burkina Faso.

Annex 1

Factors correlated with the adoption of improved seed varieties

	2010 (t-statistics)
Constant	(0,915)
Mané-dummy	0,568 (4,567)***
Gandaogo-dummy	-0,168 (-1,442)
Household members	-0,286 (-1,003)
Cultivated surface/ person	-0,083 (-0,475)
Member of group	0,341 (2,941)***
	N=49
	Adj R^2 = 0,552

*Dependent variable: adoption of improved seed. Significance at * 10 %, ** 5 % and *** 1% level*

Factors correlated with the introduction of plough

	2001/02 (t-stat)	**2010** (t-stat)
Constant	(4,596)***	(-0,928)
Surface/ labourer	-	0,50 (2,541)**
Household members	-	0,363 (1,699)*
Gandaogo dummy	0,450 (3,890)***	-
Zambanga dummy	0,276 (2,388)**	-
Mané dummy	-	0,553 (3,584)***
	N=74	N = 49
	Adj R2 = 0,159	Adj R2 = 0,274

*Dependent variable: use of plough. Significance at * 10 %, ** 5 % and *** 1% level*

Endnotes

[i] However, Hayami and Ruttan (1971) also allowed some role for the state, in providing public finance for research and development of the new technologies.

[ii] Vulnerability to poverty was defined as a risk of falling into poverty higher than 40 percent, with estimations based on extrapolations of a number of relevant household characteristics.

[iii] It is also interesting to compare the adoption of new seed varieties with the adoption of mobile phones or motorcycles. Observations from fieldwork show only a minor correlation between this and the adoption of new seed varieties. In several cases household heads were using mobile phones and motorcycles, but still did not search out new agricultural inputs, such as improved seed varieties. Different standards apply to technical changes in agriculture as compared to technical changes in everyday communications – although there are also similarities. One important difference is that young men often are the most eager to acquire mobile phones and motorcycles, but among the least interested in investing in agriculture. There are also differences in the channels for spreading communication tools and new seed varieties. Mobile phones and motorcycles are possible to obtain at various different market outlets, whereas improved seeds are predominantly distributed through centralised channels.

[iv] A dummy variable for the village Zambanga, in the Namentenga province in the central east part of the country, was also found statistically significant.

Tables

Table 1: **Use of improved seed varieties and chemical fertilizer in studied villages**

	2001/02		**2010**	
	Improved seeds (% users)	Fertilizer (% users)	Improved seeds (%)	Fertilizer (%)
Rapougouma	46	9,5	37	18
Mané	n.a.	n.a.	62	38
Gandaogo	40	57	29	58
Total sample	**47**	**33**	**43**	**37**

Source: Fieldwork

Table 2: Land use and mechanisation in three villages

	2001/02			**2010**		
	Household size (pers)	Plough use (%)	Cultivated area/ pers (ha)	Household size (persons)	Plough use (%)	Cultivated area/ pers (ha)
Rapougouma	18,8	38	0,24	17,0	37	0,31
Mané	n.a.	n.a.	n.a.	13,8	76	0,38
Gandaogo	14,6	73	0,44	11,9	60	0,47
Total sample	**17,4**	**57**	**0,35**	**14,0**	**55**	**0,39**

Source: fieldwork