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OBSTACLES TO TECHNOLOGY ADOPTION FOR SMALL AND MEDIUM FARMS IN THE ARID AND SEMI ARID AREAS OF MAGHREB RESEARCH REPORT SERIES

Coordinated by: Véronique Alary, CIRAD-Emvt/ ICARDA Tunis
With the contributions of:
Algeria: S. Mekersi (INRAA), N. Redjel (HCDS), A. Zeghida (ITGC), A. Bouguera (INRAA)
Morocco: M. Bendaoud (INRA Settat), M. Khelil (ANOC), M. Moussaoui (INRA Rabat)
Tunisia: M. Elloumi (INRAT), S. Selmi (ESI, Mograne)
France: M. Ayouz (CNRS/CIRAD), J.P. Boutonnet (INRA France)
Syria: C. Dutilly-Diane (ICARDA)
Scientific Support:
M. El Mourid (Coordinateur régional d'Afrique du Nord, ICARDA)
J.M. Boussard (INRA France)

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Summary
The agricultural sector in the Maghreb is characterized by small and medium farms (approx 3 million) that are very vulnerable due to their size and the very uncertain climatic conditions. In the arid and semi arid areas, the majority of them combine livestock activities (mainly small ruminants) with cereal crops and olive trees. The liberalization in the framework of world or regional agreements (WTO, Euro-Mediterranean agreements, etc.) may accentuate the vulnerability of these farms with the decrease of subsidies and price support. However, some of these farms hold considerable productive potential and solutions can be found through adapted institutional arrangements (including public policies, market organization), to the structural constraints related to land tenure, credit access, etc... The aims of FEMISE II project are to analyze the obstacles to technology adoption in the semi-arid and arid areas and to assess the different institutional measurements that can hamper or facilitate the technology change process. This project measures up to other ICARDA Projects in these areas, especially the Mashreq/Maghreb Project, on the "*Development of Integrated Crop/Livestock Production Systems in Low Rainfall Areas of the Mashreq and Maghreb Regions*".

The technical dimension could not be separated from the economics, organizational, institutional, social, political or even cultural components. We suppose that the innovation is partially induced by the environment of the farmers. So attention is paid to supply/demand conditions for outputs and inputs and public policies at national or regional level, institutional constraints related to land management, labor and credit at the community level and risk perception at the farm level. Some information was collected among the traders (for live animals and feeds) or the decision makers (regional authorities). A household survey in each community (60 households in Algeria, 117 in Morocco and 45 in Tunisia) was conducted for descriptive analyses and typology.

To understand the obstacles to the technology transfer, we developed mathematical programming models for each community that would allow simulating and assessing some institutional or political changes on the technology adoption process. If the models were quite similar between the communities, different modelling options were chosen: 1) the development of a stochastic model in Ait Ammar (Morocco) to understand the impact of the insurance system in an uncertain environment; 2) the use of the Positive Mathematical Programming in the Algerian community that would consider all the 60 households in the model; and 3) the development of a dynamic programming model in Tunisia and Algeria to consider the dynamic trend of the plantations and the livestock.

The review of the technologies proposed in the semi-arid and arid areas revealed an important panel of technical options (Shideed, 2002). In this work, we mainly focussed on the cactii, as an interesting option in Tunisia and Algeria, and the common rangeland improvement with fertilization and rotation in Morocco. In Tunisia, further simulations were done on feed block and vetch development in order to compare external and endogenous[1] innovations[2]. For each technology, different institutional options were associated: (1) market organization for cactus' pad; and (2) different common rules for common resources, Also, other institutional arrangements such as insurance systems or labor force regulations were tested. Finally, other simulations were conduced on input and output prices in order to test the effects of the liberalization.

The descriptive analysis of the meat distribution market revealed a set of changes: the start of a variation of prices according to the markets, the type of consumers, the social events and the season; the development and success of super markets with a new type of retail selling. These changes could influence the whole distribution channel with a decentralization of the activities of cut from the urban to the rural areas.

According to the farmers, they have relatively good information on the prices due to frequent trips to the souks and recent introduction of mobile phones that helped in getting information on distant markets. Moreover, the majority of herders are small ones compared to the past decades when there were larger herders with more than 1000 heads. So now the risk of cooperation is minor. Finally, a large part of the market is controlled by farmers during Aïd El Kebir and they are able to travel long distances. If the final sale-price for live animals is without any surprise, several events can interfere:

[1] External innovation is an innovation introduced by outsiders although endogenous innovation is an innovation introduced by the population itself.
[2] The simulations are presented and described in the French report Femise II/ICARDA.

1) the herder is never sure to find a buyer when the animals are ready for sale. Therefore, if he cannot sell at the optimum sale's time, the animal generally loses its value (age, fat content, end of the ceremonies) and it is going to cost him more for the animal husbandry; and 2) sometimes, the herder is forced to sell his animals before the end of the fattening period because of lack of resource or need of money for urgent social events. Moreover, the herders who produce lambs for fattening often feel misled and and that they are the biggest losers in the channel.

The herders who are in charge of fattening are often traders and/or butchers with some formal or informal contract with persons in charge of the slaughtering. This highly speculative activity can provide important margins in getting a good price on feeds and a good local experience on the purchase of low fat animals, especially, during Aïd El Kebir.

The high price of sheep meat can be explained by different factors among which: 1) the production is not quite flexible and depends more on the climatic factors; 2) the natural protection of the national markets due to the consumer preference of live and local lambs for the ceremonies of Aïd El Kebir; and 3) the control of the imports.

According to the farmers, the sheep market is functioning quite well and it does not constitute a handicap to technology adoption. On the contrary, the good prices would favour investments in technological improvement. But, the variability of prices is mainly due to the prevailing climatic conditions. Faced with these factors, only institutional arrangements could help farmers to invest in new productive systems.

For the cactus, the repayment period constitutes the main limit to the adoption, more than is the risk attitude. Cactus plantation as perennial crops fits well with long term view of the farm. Now, with the new tendencies, the farmers depend more on feed purchase at short term. This constitutes a constraint to the adoption of long term technology. The reduction (or increase) of the coefficient of risk aversion favour the stocking (or de-stocking) in live animals for the agro-pastoralists. Consequently. small farmers, with thresholds close to survival, have little room to manoeuvre.

Therefore, the main handicap to natural resource management options, such as cactus, is the short term management of the farmers. This justifies financial support to allow a more flexible repayment period. Moreover, as is the case for all technologies, the lack of experience and the absence of knowledge on the expected outputs limit the level of adoption. This implies more research work on the expected yields from the technology and on the development of efficient transfer methods of the information to the farmers.

One of the main stimuli of the cactus adoption is the development of a marketing channel for cactus products (pads, fruit). In the simulation, the markets for the cactus products would allow a diversification of the systems and a reduction of the dependence of purchased feed during dry years. In a context of liberalization, cactus marketing could reduce the negative impacts for the large agro-pastoralists. In Algeria, this marketing opportunity would permit live re-stocking in the small farms.

This would encourage the development of research on the different marketing channel options concerning cactus products.

Technology options might be influenced by property right structures. This is what was analyzed in the case of the common rangelands of the Ait Ammar community. Not only the decision process on the choice of technology might be more difficult in the case of common property rights than private ones, but the benefits of the technology might differ according to the farm types in the community. In addition, because common resources are characterized by negative externality in their use, technologies aiming at rehabilitating the land (shrubs, fertilization) might not succeed; the extra biomass generated being overgrazed if no management plans are settled. Beside, the interest and viability of management arrangements on common rangelands (such as access regulations and entry rights) reveal very controversial results when the demographic pressure on the resource is too high, as is demonstrated in the Ait Ammar community (Morocco).

Interventions on wage conditions have few impacts on the technical changes. The actual reduction of off-farm opportunities (mainly for non skilled labor) could question one of the main pillars of survival for the small farms in Tunisia. In the large farms, the off-farm activities seem to imply more

productive changes than technical changes; it seems that off-farm income allows development of a fattening activity.

One interesting option for these areas is the establishment of an insurance system, as is the case study in Morocco. All the farms seem to be ready to subscribe at different levels, and the system can play an important role in risk management in these uncertain environments. But, this system implies some public intervention in a period that advocates the reduction of public expenditures. However, the development of specific insurance systems based on livestock activity needs greater attention from research.

We can say that the model constitutes an interesting tool to simulate different scenarios and analyze the interactive effects of economical and technical changes (such as, liberalization and cactus market implementation), or even technical and institutional changes (such as, the entry tax and fertilization on common rangeland). But, the aggregation can constitute a limit to approach the individual behaviours and their heterogeneity. The Algerian model is thus original by taking into account the set of the farmers (60 households) in the model. But, this implies the use of other ways of calibration.

These models do not integrate the whole complexity of the interactions of the agents, either at the market or the community level. This implies development of a more sociological approach as a first step and, in a second step, to develop new modeling approaches such as multi agents models to integrate social constraints. These are the two main recommendations.

1. Background

1.1. General context and objective

The agricultural sector in the Maghreb is characterized by small and medium farms (3 millions) that are very vulnerable due to their size and the very uncertain climatic conditions. In the arid and semi arid areas, the majority of them combine livestock activities (mainly small ruminants) with cereal crops and olive trees. These zones are facing many handicaps among which:

- The land tenure is generally very sketchy with many problems of inheritance and without property rights; this absence of property rights constitutes difficult access to credit and more generally to develop a long term plan that would integrate sustainability of the system. In the fertile areas, the land fragmentation due to the demographic pressure generates new social and environmental disequilibrium.
- High variability of producer price due to climatic conditions and absence of producer's organizations; and strong dependency on market due to natural resource degradation and difficulties to stock inputs due to their isolation and lack of credit.
- Low productivity due to land degradation and low-cost production systems.

The liberalization in the framework of world or regional agreements (WTO, Euro-Mediterranean agreements, etc...) may accentuate the vulnerability of these farms due to the decrease of subsidies and price support. These changes would lead to a decrease of cereal prices (Radwan and Reiffers, 2003) and an increase on price fluctuations, although, the specific demand in small ruminants (SR) during Muslim ceremonies (Ramadan, Aïd El Kebir) constitutes a natural hindrance to liberal markets. In this context, farmers could attempt to increase their productivity through intensification, diversification of their activities, or even, development of a low cost system. If off-farm diversification had constituted an important mechanism for funding and developing agricultural activities in marginal areas, it becomes difficult and scarce in the new national and international context due to emigration controls, decrease of national demand in non skilled labor, and high unemployment in the Maghreb countries.

However, some of these farms hold considerable productive potential and the question is to find solutions, through adapted institutional arrangements (including public policies, market organization), to the structural constraints related to land tenure, credit access, lack of skills for added-value products etc... (Akesbi, 2003). These are very fragile farms, close to the threshold of survival, that need social measures. Therefore, the liberalization should be analyzed in this diversified and vulnerable environment.

The aims of FEMISE II project are to analyze the obstacles to technology adoption in the semi-arid and arid areas and to assess the different institutional measurements that can hamper or facilitate the technology change process. This project compares favourably with other ICARDA Projects in these areas, especially the Mashreq/Maghreb Project (M&M project), on the "*Development of Integrated Crop/Livestock Production Systems in Low Rainfall Areas of the Mashreq and Maghreb Regions*". This was a collaborative project between the national programs of eight countries in the West Asia and North Africa (WANA) region, i.e., Algeria, Iraq, Jordan, Lebanon, Libya, Morocco, Syria, and Tunisia, ICARDA and IFPRI. The project was supported by the International Fund for Agricultural Development (IFAD), the Arab Fund for Economic and Social Development (AFSED), the International Development Research Centre (IDRC), the Ford Foundation and the CGIAR System-wide program on Property Rights and Collective Action (CAPRi). The M&M project was initiated in 1995 and implemented in two phases, 1995-1998 and 1998-2002. In this project, the research and technology development to improve feed and fodder production through-out the arable sector, as well as from rangelands, mainly focused on the feed block technology, barley production, stored forage in *situ* (Cactus, *Atriplex*) and livestock management.

The objectives of FEMISE project are to understand the obstacles to the adoption of technologies and to analyze the institutional arrangements, including market organization, public policies, property rights on rangeland management, etc... that may facilitate or check the technology adoption related to livestock systems, a system that is considered as a major component in agro-pastoral areas, although, many farmers did lose a large number of their herd following the last drought. In this regard, attention is paid to the whole management and dynamics of farming systems in the arid and semi-arid areas in the Maghreb and also on the previous and actual policies.

1.2. Brief review of the literature

The progressive changes in the agro-pastoral systems reveal the important gap between livestock activity and natural resource management and show an increasing dependency on the market. In this context, the increase of productivity is one solution. All the Maghreb countries experienced the Green Revolution with its technical package that was largely sustained by subsidies. But, little impact was observed in the rainfed arid and semi-arid areas.

The unsuccessful story of technology transfer in developing countries had led to an overwhelming scepticism, or moreover to abandon these marginal systems. Economists pointed out several factors that might explain this low technological adoption: (1) the human capital (Ruttan, 1977; Bayri, 1989; Arrow et al., 1961), (2) the lack of capital with limited access to credit (Jansen et al, 1990), and (3) the labor constraints (Bayri, 1989; Aresvik, 1976; Lanzendorfer, 1985). Risk perception and risk taking by farmers in an uncertain environment were also reported. In harsh environments, farmers are considered as risk adverse (Rahahela, 1989; Binswanger et al., 1978). Finally, the land capital.- this is a controversial issue; in fact, while Aresvik (1976) considers land capital and land property rights as obstacles to technology adoption, Ruttan (1977) and Feder et al. (1984) demonstrate that neither the size nor the land tenure are constraints to adoption.

During the eighties and nineties, research studies on the whole farming systems changed the view and considered the farm as an equilibrium system between resources and objectives. Studies on the local knowledge and farming practices showed the undeniable technical competences of the farmers and their ingenious and shrewd character. The dynamic approach to the farms points out the technical and organizational adaptive skills of the farmers. Regional studies underlined the strong interactions and complementarities between different rural areas, and also between urban and rural areas, in term of both diversification and marketing. However, in this scheme, if the farmers have good reasons to refuse the technologies, the analysis could overestimate the endogenous capacity of creation, innovation and adaptation in an uncertain environment.

On the basis of this farming system approach, more multidisciplinary research work was attempted to develop technology packages based on local knowledge and social organization. , Increasing attention was given to the development of sustainable systems that integrate the preservation of the environment, however, the technology adoption indicators remained quite low in the arid and semi arid areas (Belaid, 2001).

The M&M research project, in collaboration with national institutes in the area, developed an integrated and community approach of the agro-pastoral systems. The main hypothesis was that technology diffusion needs institutional arrangements in a whole package. These arrangements could be producers' associations, community agreements (for rangeland management), public agricultural policies, etc... The community approach was mainly based on a partnership between the farmers, developers and researchers, and on the organization of regular meetings. The selection of developed technologies resulted from the expectations, the problems and the advantages to the farmers. At the same time, linear programming models were developed to assess the impacts of political changes on the technology adoption, and the efficiency and equity at the community level. The project FEMISE I then tested the model in two communities, one in Algeria and the other in Jordan (Chaherli, 2000). The results showed important heterogeneity on the effects of political changes between the two communities and also, between the different farms according to their initial endowment (land, flock, labor, etc...).

But then, innovation takes place in the dynamic of the farming systems in interaction with their environment. Therefore, the integration of the dynamic process in the model could allow approaching the adoption process. The technical dimension could not be separated from the economics, organizational, institutional, social, political or even cultural components. Innovation is induced by the environment of the farmers. In this regard, we proposed to integrate the market conditions, the institutional environment (especially, credit access and insurance system) and organizational environment (as related to the management of common pasture-land).

2. Hypothesis and methodology

2.1. Hypothesis

In order to understand the obstacles to technology transfer, we seek to develop a dynamic programming model for each community that would allow simulating and assessing some institutional or political changes on the technology adoption process. For this and to have a good representation of the community, it is important to consider the external environment that affects the decisions-making Process. Attention is paid to the conditions of supply/demand for outputs and inputs, to public policies at national or regional level, to institutional constraints related to land management, to labor and credit at the community level, and to risk perception at the farm level.

2.1.1. Complexity of marketing strategies and hypothesis

In the context of liberalization, the under-privileged and isolated areas are generally very vulnerable. This is due to the high production and transaction costs. In the degraded areas, in fact, the herders are often constrained to resort to the market for concentrated and grain supply. During dry years, the complementation accounts for 90% of the sheep ration. Moreover, without producers' organization, the herders either purchase their inputs at full price or sell one part of the flock. The input price is affected by three major factors: (1) public policies, especially, subsidies on barley grain, (2) climatic conditions (that explain variations of two or three times), and (3) decisions of farmers in favorable areas who can keep or sell their stock. In Morocco, the large producers may stock the cereal straw for more than 2 years waiting for a bad year in order to sell at a higher price. These behaviors, especially, during dry years, create important tensions on the markets.

For the meat market, the herders are obliged to make many trips to the markets to have good information on prices. For the Aïd El Kebir ceremony in 2003, a Tunisian herder made visits to the three markets of his region (Sidi Bouzid in the central Tunisia) during the last three previous weeks in order to record price fluctuations and decide on the moment to sell. With the local and oral information on the Tunis market via mobile phones, the farmers decide on the time and place to sell. The eldest farmers prefer selling at the local markets in order to avoid the risks of aggressions and the precarious conditions in the large towns. The youngest farmers are also reluctant to leave their women and children alone in the village without male adults. Marketing strategies differ, then, according to the stage of the family.

For the large agro-pastoralists, production strategies, i.e., purchase of lamb for fattening, feeding system, etc... depend mainly on marketing strategies that privilege Aïd El Kebir event. Although, at this period, prices are very uncertain because of relative rigid demand and very elastic supply

according to the climatic year (random factor), the political actions (meat import, control of the informal border market, etc...), and also, the mimetic behaviors of the farmers. For example, during the month of Ramadan 2003, Tunisian farmers kept all their animals although the sheep price was around 250 DT per head. This stocking behavior was possible due to the good year, but, also by mimetic behaviors of the farmers who were preparing for the Aïd El Kebir. Nobody tried to sell the animals during Ramadan. In the Moroccan and Algerian communities, the last drought (1998-2002) destroyed a large part of the sheep herd for the majority of farmers. Then, the marketing decisions were made to keep and rebuild their animal stock, and balance their cash flow.

All these elements underline the complexity of marketing strategies which depend on the stage of the family, the stage of the herd (rebuilding, expansion, and stability), the market periods, the climatic conditions, etc...

Moreover, it is difficult to recompose supply/demand curves that are established at different regional and national scales. The observations reveal great movement of the flock and the farmers may rent a taxi or a pick up, alone or together, to sell their animals. The mobility of animals strengthens exchanges between areas. This implies taking into account the geographic conditions of supply/demand for each input and output.

The prices depend not only on the market, but also, on the fixed factors and institutions that imply different scales of negotiation, from the individual, the community, the region up to the national and international levels. The decisions at each level depend not only on the subordination relations, but also, on the mechanisms of propagation or negotiation between each level. They are inter-dependants and transit via information channel that include the prices, their variability, the rules or rights at the community level, the institutions (for example, the credits), the infrastructure and the marketing system (J.M. Boussard, 2003, cited in Alary and al., 2003). There is also an under-estimation of the role of traders in the innovation process and the information comes often from suppliers. All these lead to integrate the behavior of many actors who interact via different information channels that each could be represented by equilibrium constraint. However, the actors act at different scales and it is very difficult to establish this equilibrium at the community level.

Finally, the prices change with the environment in which interact endogenous and exogenous institutions. For the three Maghreb countries, although the consumer price for meat is controlled, the negotiations on the weekly markets are more or less free. The direct or indirect interventions on prices allows some ranges of variation for prices. But, other factors, such as, the absence of systematic weighing of animals and the different assessment of the quality also intervene.

In this study, attention was paid to the marketing strategies of farmers with regards to operations of purchase or sale of animals or of supply in inputs. A qualitative approach of the meat channel allowed putting these marketing strategies in the channel system. This analysis led to different hypothesis on the expected prices for live animals and marketing strategies during the year that they were integrated into the model.

2.1.2. Institutional constraints and hypothesis

The second objective was to analyze the impacts of institutional changes on the behaviors and livelihoods of farmers in arid and semi-arid areas. Are there some institutional changes that could facilitate the adoption of technology, increase the productivity and income and offset the effects of the liberalization?

In arid and semi arid areas, farmers have diversified in and out their production systems. Off-farm activities have always constituted a driving force to modernize the production system (by investment of the off-farm incomes in the production system) or a buffer to face unfavorable climatic conditions. Elloumi (1991) distinguished three roles of the multi-activity and off-farm incomes: (i) maintaining the family livelihood; (ii) modernizing the agricultural production systems, and (iii) investment. For these different forms and roles of the multi-activity, the wage and the opportunity cost differ. But now, the world context implies restrictions for non-skilled labor emigration; this non-skilled work force has difficulties finding jobs within the country. All the Maghreb countries suffer from very high rates of unemployment. In this context of restriction of job opportunities, how can the farmers resist? Moreover, the off-farm incomes were the driving force in the agricultural capitalization and,

generally, the innovation process requires some investments. In this context then, the farmers may limit the technological changes in order to avoid capital mobilization. Therefore, it is proposed to test different employment changes on the adoption level.

At the community level, the main exchanges or interactions between herders concern the management of stubble grazing after harvesting cereals and the common grazing of land which may be a common or a public good. The exchanges of land (for renting or sharecropping) are quite limited in the Tunisian and Moroccan communities, due to latent conflicts between social fractions or within the enlarged family. In Algeria, they are more important because of the emigration.

The access to collective resources such as the pasture-land may be regulated, controlled or even constrained at the community level through a set of implicit and explicit rules between farmers or between farmers and an institution in charge of this pasture-land (cooperative or public agency). The lack of community rules leads to individual and opportunistic behaviors with great risk for the resources. The pastoral resources' trend depends, though, on the rules and their respect by the different users. The slightest deviation could generate social, economic and ecological disequilibrium. It is proposed to assess the impact of different institutional agreements on the technology adoption on common resources.

Finally, a major factor that can change the farmers' decision is the political environment, especially the agricultural policies. If the price policies concern all the farmers, two types of intervention are mainly focused on the arid and semi-arid areas: the drought mitigation policies and the public support for the development and diffusion of adapted technologies for these areas.

The three Maghreb countries experience the liberalization with the subsequent reduction of subsidies on the inputs and price support on the products. But, the liberalization is quite controlled. In Morocco, cereals and meat still belong to groups of controlled products. If the meat price is controlled less, the Moroccan government maintains important import taxes, around 250% for red meat (Moussaoui, 2004). In Algeria, the cereal trade is completely controlled by public organisms. In Tunisia, the free market for meat dates back to 1980, and the government intervenes regularly on this market during strategic events (Aïd El Kebir for instance) to limit the leap in prices. Only the reduction of subsidies on inputs is effective, but still, only few farmers use chemical fertilizers or treatments in the semi-arid and arid zones.

The more spectacular intervention is the drought mitigation policy, developed first in Morocco and extended to Algeria and Tunisia. These policies aim mainly to avoid de-stoking during drought period owing to the low-cost or free distribution of barley grain. Other actions concern the rescheduling of debts, the reduction of import tax, the compensation, etc... Except for Morocco, the governments have not attempted to elaborate a foresight system to regulate more efficiently the regular and structural droughts. In Morocco, an insurance system is actually experienced in the favored areas. It is proposed to test this system in the arid and semi-arid areas. In fact, in these agro-pastoral societies, the credit access is very limited. First, because in the absence of irrigation, the farmers are completely dependant on climatic conditions and the banks are reluctant to fund agricultural activities without any insurance. Second, in these communities, the cultivated land is often in jointly-owned property without title deed that constitutes a guarantee to require a formal credit. Finally, in communities or for some social fractions, some people would be reluctant to request credits with rates of interest that are banned in the Muslim religion. If many farmers receive informal credits from enlarged family or neighbors at the community level, these credits are generally reserved for social urgent needs. So, the question is there a possible insurance system in these risky areas?

For the last decade, policy makers are more aware of the dangers of desertification in the arid and semi-arid areas. More attention is given to the development and diffusion of drought tolerant plants or fodder shrubs (such as Cactus and *Atriplex*) to preserve these areas. Some institutional agreements are also attempted to limit opportunistic use of the resources. It is also essential to develop extension services.

Therefore, from the analysis of the behaviors of the farmers, the question is whether institutional changes could facilitate the technology adoption? Our attention is focused on the impacts of labor change, common resource management and policies of liberalization on the adoption level.

2.1.3 Risk perception and risk taking

The risk has always been considered as a major factor that limits the adoption of new technology (Rosenberg, 1976; Lindner et al., 1987; Just and Zilberman, 1983; Marra, 2001). The sociologists first considered the perceptions of the technology by the adopters and non adopters, and also, the different information channel in the diffusion process. Marra (2003) proposed to distinguish different elements of risk: the decision process, the learning process, the farmers' perception on the present and future probabilities distribution of the expected gains of the technology, perception of the covariance of the outcomes between the old and new technology, the risk attitude and the pay-off period for the investment. Two economic approaches were developed: one on the investment decision in uncertain environment, and the second, on the relations between the risk induced by the technology and the risk attitude by the farmers.

We note that in the majority of studies, the uncertainty related to the future value of one investment is considered as a factor of limitation to the adoption, and refers mainly to the financial sector (Arrow et Fisher, 1974). These studies reveal also the high interest rates due to the repayment period, the uncertainty on the future values and the induced cost due to the disinvestment. These results confirm the necessity to establish buffer prices to reduce the uncertainty due to the investment (Chavas, 1994); this explains also the waiting period and attitude of the actors (Zhao, 2000). Just and Zilberman (1983) proposed the first theory of adoption based on the expected utility. For these authors, the degree and rate of adoption are limited when the covariance of gains between the old and new technology is high and when the risk aversion with the increasing of the wealth is decreasing.

Many empirical works showed the difficulties to approach the risk and uncertainty considerations. The estimations of subjective probabilities of the yield distribution are changing every time with the degree of information (O'Mara, 1980; Smith and Mandac, 1995). From the analysis of the preference for risk in an Indian rural case study, Binswanger and al. (1980) underlined the very contrasting situations between risk taking and level of wealth. Kebede (1992) showed that off-farm income could reduce the risk taking in agriculture. Shapiro et al. (1992) came to the conclusion that the adopters have an adverse risk attitude compared to non adopters and that, at the end, the risk perception is more important in the decision process than the risk preference.

Other research works are more focused on the role of information and the learning process. Some authors showed that the efficiency of a new technology increases with experience (*learning by doing*) (Warner, 1974; Linder and Pardey, 1979). Other studies tried to approach the cost of access to information from the level of education, the distance between adopters and non adopters, the availability of extension agents (McNamara et al., 1991; Cambrezy, 1999). Others privileged the quality of information through the estimation of the subjective distribution of the yields (Fischer et al, 1996) and the processes of '*learning by doing'*, i.e., the acquisition of the information (Abadi Ghadim, 2000 ; Marra et al., 2003).

Our study focuses on technologies that were developed and adapted to arid and semi-arid areas (technologies such as Cactus plantations). We propose to test the role of risk attitude on technology adoption. The Cactus is a perennial crop that requires important investments without any products the first three years. In a risky environment, farmers often have short term management, and the question then becomes – is this an obstacle to their investment and does it justify the preservation of subsidies?

2.2 Choice of the technology and the communities

2.1.1 Choices of the technologies

The review of the technologies proposed in the semi-arid and arid areas reveals an important panel of technical options (Shideed, 2002). But, the levels of adoption are quite low, except, for cactus in Algeria and Tunisia and for barley seed in Morocco (table 1). Our objective is to test the impact of institutional changes on the adoption levels. We focused our work on cactus which is considered as an interesting option in Tunisia and Algeria, and on the common range-land improvement with fertilization in Morocco. In Tunisia, some simulations were done on feed block and vetch development in order to compare external and endogenous innovations. For each technology, different institutional options were associated: 1) market organization for cactus pad, and 2) different common rules for common resource. Other institutional arrangements, such as, insurance system or labor force

regulation were tested; and the objective was to see if one of them stimulated any technology). Finally some simulations were conducted on input and output price in order to test the effects of the liberalization.

2.1.2 Description of the technologies

Well adapted to harsh environments in the dry areas, cactus represents an interesting production option for farmers as a feed source for the animals as well as a mean of protecting the natural resource by controlling soil erosion and water loss. Introduced in the 17th century to North Africa upon the return of the Moors from Andalusia (Nefzaoui et al., 2002), the cactus could not be considered as a new technology. In the M&M project, attention was given to the development of spineless cactus grown either in alley cropping in Tunisia or in the plain in Algeria. Alley cropping is an agro-forestry practice where perennial crops are simultaneously grown with an arable crop. Alley cropping is a form of hedgerow intercropping. Traditionally developed with legume species, using cactus in alley cropping systems is a new practice. Cactus may serve in the system as windbreak and also for water conservation which would result in improved grass/cereal yields. Furthermore, wide alley may allow animals to graze biomass strata or cereal stubbles in summer time. In both study cases (alley cropping or in plain), cactus pads may be harvested and chopped into small pieces and be given directly to animals as energy supplement of low quality stubbles.

From the typology of technology developed by Lefort (1988), cactus is not a technology that induces transformation, but change. According to the typology of Recquier-Desjardins (1999), it is within keeping with an incremental innovation process, i.e., without radical change, but, with the possibility to create new market opportunities.

In Tunisia, two other technologies were tested: feed block and vetch. The feed blocks are composed of agro-industrial by-products or residues from olive or tomato plants. Reduced to small blocks, these products are easy to transport and kept in storage. Moreover, their production requires low investment. Vetch is a fodder crop well adapted to soil conditions in these areas. Both technologies induced some changes in the feeding systems and could be considered as "additive" (Lefort, 1988).

If this report mainly focuses on cactus technology, results obtained on feed blocks and vetch technologies are presented in the French report (FEMISE II/ICARDA).

2.1.3 Brief description of the communities

The three communities studied were selected within the framework of the M&M project (ICARDA). These communities are located in dry-lands with less than 350 mm rainfall and characterized by periodic droughts. The production systems are dominantly agro-pastoral systems, and people derive their incomes from both livestock and crop production.

In Algeria, the community is located in the Sidi Fredj commune (Wilaya of Souk Ahras) in the North East of the country. This community counts 840 households and 25% of the total area (25 000 ha) are pastoral land (forest, pasture). The main cropping system comprises barley grain for animals, durum wheat for self consumption and bread wheat for selling. In 1999, the livestock activity provides 70% of the agricultural income. In the last decade, a rapid decreasing of shepherd (25%) was registered. Although, in the last two years (2002-2003 and 2003-2004), the trend was inversed.

In Morocco, the community selected is Ait Ammar in the Kouribga province. It is composed of two main social fractions, Osimba and Osibra. It counts 447 households in total and 7900 ha agricultural area. The two community fractions are located on two parts: Osibra fraction is in majority located in the southern part with good agricultural soil, and Osimba fraction is located in the Central and Northern part with shallow soil (see figure 1).

In this community the pastureland is the main pastoral resources. It is shared by the members of the community and its management is based on informal agreements.

In Tunisia, the selected community Zoghmar is located in the central part of the country. This community counts around 396 households and 4300 ha agricultural area. It has three social fractions. An irrigation perimeter of 120 ha was implemented in the community in 2000-01. It concerns 52 farmers only (13% of the population). This irrigation perimeter has induced important changes at the community level. Distinction now in the community is made between farmers with and without

irrigation. Considering this new change, how are the technology based on drought mitigation considered?

2.3 Methodology

Two methodological approaches were developed in this study: 1) a holistic approach of the different farming systems to test the impacts of the technology and 2) a vertical approach to approach the market channel.

2.3.1 Holistic approach of the farming systems: from the survey to the model

Earlier experience shows that the impact of different development projects (including technology innovation) in a homogeneous agro-climatic and socio-territorial area is quite variable (Aubry and al., 2001), and depends on the types of farming systems, the objectives at the family level and the mode of introduction of the project in term of relationships and coordination between agents. The farming systems are complex units that combine cropping systems, livestock systems and decision system (family, rules, objective). These three systems are completely interlinked with some complementarities, competitions and synergies relations. The farming system approach, then, allows considering the interactions between the different activities in the use of the resources (land, water, pasture land) and the allocation of the different factors (labor, inputs) between the sub-systems according to the objectives of the farmers and their perceptions of the environment.

In this study, a set of household surveys were conducted in each community of the three countries. These surveys focused on different aspects:

- The family composition and characteristics (age and level of education of the head, number of active, scholars, main social expenditure, etc...).
- The capital (land, equipment, animal stock).
- The cropping systems: allocation of land, level of intensification, production.
- The livestock systems: flock composition, selling/purchasing management, feeding system.
- The institutional constraints (credit, input supply, meat market).

The size and mode of sampling differ for each community:

- In Algeria, 60 households were chosen at random and surveyed in June 2003. In January 2004, 23 of them (who count more than 10 ewes) were revisited to analyze meat marketing strategies.
- In Morocco, 87 households were chosen at random and surveyed in March 2003. In November 2003, a second survey on the use of the collective pastureland was conducted. The objective was to understand the relationships between the herders in the use of this resource and the modalities of management. In March 2003, 61 farms were surveyed; 31 of them were surveyed before and 30 were new farms that use the pastureland.
- In Tunisia, data were collected from a cross sectional sample of farmers within the target area. The sample used was selected on stratified random sampling, depending on the main farming systems in the area. These surveys gave an (unbalanced) panel data of 45 farm households from Zoghmar community, surveyed in 1999, 2002 and 2003. The survey conducted in April 2003 aimed at analyzing the marketing strategies of the farmers with regard to animals.

These data were used for elaborating and analyzing the different types of farming systems in each community. The objective of the typhology was to recompose the farming systems and analyze the diversity at the community level. It was also possible to analyze the different forms of exchanges between the types of farms within the community. These different types of farms constitute the farmers represented in the community model.

The second step was the re-composition of these types of farm in a model. The objective was to have a tool to understand the behaviors of the different types of farms and simulate the impacts of institutional changes on the level of adoption of the different technologies. Technical choices are quite complex and depend not only on the decisions at the whole farm level (objectives, resource endowment, off farm opportunity, risk behavior, etc.), but also, at the community level. Some exchanges of factors (land, fodder stock) or capital (informal credit) could influence the farmers' decision. These decisions concerning investments depend on a combination of experience (observation of productivity change, the climatic succession, the community perception) and trade-off

between present and future. This trade-off is sensitive to change with household orientation (off-farm orientation, return of the oldest son, for example) and resource endowments (land property rights).

If the classical econometric models based on statistical data allow approaching the determinants of adoption and the expected results in term of productivity and efficiency, they constitute limited approaches to integrate the complexity of the whole system with its three dimensions (socio-economic, bio-physical and environment) in an identical schedule. Within this framework, dynamic bio-economic models based on decision process models offer interesting approaches (Barbier, 1998; Deybe, 1998; Pittrof, 2002). Their main advantages are to model competition, interactions and feedback effects between the different sub-systems and the possibility to integrate various competing or complementary goals (marketing behavior, allocation of resource to farm and off-farm activities, consumption choices, environment). Without ecological data on the biomass trend, nutrient cycle, soil conservation, we used "engineering production functions" in the economic model; these functions result from *in situ* research on-farm trials.

This model was used as a descriptive model in order to characterize and to understand the different systems, but also as positive models that describe what ought to be done and how certain objectives could be achieved at the individual or collective levels.

The model integrates the complexity of the activities at the whole farming systems, the individual technical and socio-economic constraints that limit or condition the adoption, and the common constraints due to social or economic arrangements in the community. This model includes four modules:

(i) Farm household module that specifies the underlying behavior relations between household resource allocation and consumption priorities;

(ii) Input/output module for crop and livestock activities that describe fully technological coefficients for current and potential activities;

(iii) Optimization procedure to evaluate household responses to changes in the market environment;

(iv) Module of aggregation that tackles tradeoffs between individually owned production factors (mainly land and labor) and access to common resources at the community level.

The originality of this model is to represent interrelations between the different components of the farming system: livestock system and cropping system in term of resource supply/demand competition and/or complementarities and the interrelations between the socio-economical system, including fund management (cash flow, credit, etc.), and the bio-technical system that explains why farmers do not or cannot choose the technical or economic options considered as the best or the optimal figure 2 represents a sample schedule of the model.

The community model represents a simplified picture of an aggregation of typical whole farm systems. These typical whole farm systems are identified through cluster analysis on the database issued from the household surveys. Each farm is characterized with its different resource endowments (land, labor and capital) and its management (crop and livestock systems, and family objectives). The farmers interact among themselves through exchanges of factors, like non-storable fodder, labor forces, land, and credits. At the community level, the farmers are linked to the market for input purchases and output sales and the institutional environment for credit access or land and labor access.

The model developed relies on a standard mathematical programming formulation (Hazell et al., 1986; Boussard, 1971). Here, it is the maximization of the net income function (including animal stock) under constraints of resource endowment and technical opportunities. To consider the trade-off between the present and future, we developed a dynamic model. Risk behaviour is one of the main factors to explain technology adoption. This risk behaviour will depend on farms' characteristics (diversification, capital endowment, characteristic of the head of the family, etc...), the market conditions and the technology perception. The risk taking is formulated under the Target Motad approach proposed by Tauer (1983) at the individual level.

If the community model constitutes the same framework for the three communities studied, some specific adjustments were to be realized. In Morocco, in order to test the insurance system, the stochastic discrete programming approach was used (Cocks, 1968). It is a useful approach to integrate

the random climatic risk. The constraints are expressed with the variables defined for each state of nature (X_{ir}). With (b^j_{ir}) the technical coefficients and (B_r^j) the resources, the constraints are written:

$$\sum_i (X_{ir} \cdot b_{ir}^j) \leq B_r^j . \quad \forall r \forall j$$

Then, the objective function is the weighting sum of results obtained for each state of nature:

$$\pi = \sum_{r,i} (P_r \cdot X_{ir} \cdot C_{ir}) .$$

With i the activities, (P_r) the unit price of each activity, (X_j) the variables of decisions, (C_j) the economical coefficients and π the income.

In Algeria, the positive mathematical programming approach (PMP) was used for the validation (Howitt, 1995, 1998). The PMP method allows calibrating the farm models using a restrictive set of variables. In this method, a non linear function that allows reproduction of the observed situation and smoothing of the results of the scenarios was used. The non linearity can be introduced in the objective functions either in receipts (Howitt, 1995a) or production costs (Arfini et Paris, 1995). In our case, a non linear function of cost in which the parameters sum up the non available information was specified (Alary, Ayouz, Mekersi, 2004). The originality is the integration of the set of farms in the model and not the types of farm.

In Tunisia, irrigated activities, such as, vegetable or fodder crops (sorghum, oat), and the dynamic of perennial crops (cactus, olive trees) were introduced in the model. The objective was to analyze the effects of the time and risk attitude in the decision process of farmers.

The calibration and validation of each model are presented in the national case study (Bendaoud, 2004; Alary et al., 2004, Ayouz et al., 2004).

2.3.2 Approach of the marketing channel

The objective of the marketing channel approach is to understand the constraints due to market in the decision process of farmers. Our approach focused on the farmers' marketing strategies and specific surveys were conducted in the sampling population of each community to analyze the decisions of purchase and sale. Besides, in order to capture the role and impacts of others actors for the meat channel, some complementary surveys were conducted in the different animal markets or "souks".

In Algeria, informal surveys were conducted to analyze the impacts of the Algerian-Tunisian border market on the stimulation or not of the livestock activity. This survey attempted to capture the modalities of the transaction, although, the sensitivity of these informal transactions prevents collection of precise data on the exchanged stock and price.

In Morocco, 24 intermediaries were surveyed. Nine of them were local traders and the others came from different regions, as far as Essaouira. Another 28 herders in the community (around 4-5 farmers for each type of farm representative of the community) were also surveyed. The questionnaire dealt with the transactions of animals during the year (from February 2003 to January 2004), the modalities of the transaction (period, price, and place), and the origin of the traders. The study of supply/demand was conducted on 5 local markets in the region. To achieve this, information was collected near the tenants of each souk.

In Tunisia, two surveys were conducted during Aïd El Kebir in February 2003 and during Ramadan in October-November 2003. The sample comprised 12 butchers, 50 traders and 49 consumers. This sample is equally distributed between three local markets in the region of Sidi Bouzid and three urban markets in Tunis. The choice of markets was completely related to the places that were visited by the farmers of the community.

The objective of these surveys was to rebuild the different trajectory of animals from the farmers until the consumers and to understand the modalities of transaction. Are there any arrangements or informal conventions on the markets? Who decide on the price? What is the leeway in the negotiation?

It is worth mentioning that there are very few studies on meat channel in the Maghreb. Moreover, in this type of survey, one is faced with the difficulties related to the confidentialities of some information, or to the informalities of the transactions as in the Algerian case study. The lack of time does not allow scaling up the survey at the regional or national level. This prevents the elaboration of supply/demand functions in the model. So, this descriptive analysis allows us to understand the transaction modalities and to deepen the knowledge on marketing strategies of the farmers who were included in the different models, especially, the seasons of transaction, the prices, the margin and prices fluctuations.

3. Brief presentation of the different farming systems

3.1 Global presentation of the trend of the agro-pastoral systems in North Africa

In North Africa, dry-lands with less than 350 mm of rain and periodic drought are traditionally the domain of agro-pastoralists, deriving their incomes from both livestock and crop production. These agro-pastoral systems include a wide range of production systems, ranging from semi-nomadic systems to sedentary systems (agricultural farmers who consider livestock as an asset or herders who diversify their agricultural speculations). The main difference between agro-pastoral systems and intensive crop and livestock systems is that the former consists of larger herds, and it usually relies on some kind of pastures or rangelands. Intensive crop and livestock systems are more frequent as land shortages force agro-pastoralists to intensify their production or to develop irrigation. But, in many developing countries, during the colonisation period and, subsequently, the national land reforms, many governments focused their efforts to settle nomadic or semi-nomadic people with large research and development programmes. The purpose was to increase incomes from cropping systems. These policies resulted in: tax collection, cereal food security, control of social communities and territories, benefit of land opportunities, etc... but, they caused major changes in the ecosystems and an irreversible change of traditional systems (Abbab et al., 2002; Ben Saad A., 2002).

If the traditional systems were based on common pasture controlled by tribal communities (that ensured rules of use of pasture resource), today, there are increases in the use of crop residues in the animal diet as feed grains and also the use of other concentrates are becoming common across the vast semi-arid 'steppe' zones (100-400 mm annual rainfall) stretching from Morocco to Mongolia (Nordblom et al., 1997). In North Africa, *in situ* stored forage (A*triplex,* acacia, cactus, etc...) is extending. Fodder crops (green barley, berseem, sorghum, vetch, and oat) are limited to irrigated areas. The majority of agro-pastoralists extend cereal crop production, mainly wheat for self consumption and barley for animal feed, on marginal lands although cereal yields vary considerably from year to year depending on the total amount of rainfall and its distribution. But, one common factor in North Africa is the drastic reduction of both resource rangeland to cover feed requirement with a decrease from 65% in the beginning of the 20th century to less than 10% (Nefzaoui, 2002), and the structural component of supplementation in the feeding system, inducing both an increase of risk market and a large dependence on public support during drought conditions.

In this study, we focused on three agro-pastoral communities selected in the semi-arid areas of the three Maghreb countries, Algeria, Morocco and Tunisia. The transhumance is limited to short distance from the community and the farmers combine cereal crops and small ruminants. Some of them are diversifying with olive tree, one dairy cow or vegetable when irrigation is present. This is the case for a small portion of farmers in the Tunisian community. The social, institutional and policy changes in these countries induced deep changes in the traditional systems by increasing dependency on public support and market due to the degradation of the pasture-land. Moreover, increases in water shortage raise questions to researchers and policy makers in order to consider water conserving production systems, and in many cases, these will involve traditional extensive systems rather than intensive systems.

These agro-pastoral systems show similarities of change in the traditional production patterns. These changes are as follow (Alary and al., 2001):

(1) First, in livestock production strategies, the main objective followed was to maximize benefit from the natural resource base, within the limitations imposed by the natural environment constraints. Multi-species herd composition was one way to explore the overall potential of the pasture. A key

factor of control appeared to be the natural or managed lambing period fitted to provide sufficient resource or improved protection to the new-born animals during the crucial period of pregnancy and milking. Today, this maximization is compromised with the increasing scarcity of resources due to overgrazing, encroachment, demographic pressure, etc..., and the farmers are becoming more dependant on cereal production (straw and barley grain) and markets for input supply.

2) Due to erratic climate changes in harsh environments, it was hardly possible to obtain technically optimum lambing during a short period and livestock keepers. Continuous adjustment was needed in the animal numbers in order to match available feed resources. The decision system appeared as a complex hierarchical system for designing an adaptive strategy owing to a series of sequential decision making processes. The drought mitigation policies based on grain subsidies have changed the system in the sense that farmers may maintain their flock during dry years. These policies are designated as responsible of the high degradation of rangeland due to overgrazing during dry years that damaged the pastureland beyond its threshold of resilience.

If the animal production strategy is always made of (i) a general provisional plan of spatial and temporal organization of the relationship between herd reproduction, production and selling patterns and the patterns of land use for grazing and conserved forage reserves, (ii) a general decision rules for tactical adjustment of the configuration of the system at key periods within the year according to the specificities of each year, then, the systematic use of market inputs allows some flexibilities with regard to climatic conditions. Before accumulation, depletion and replenishment of livestock, stock numbers were often consistent with the opportunistic grazing strategies rather than marketing strategies (Stanford, 1982). Today, this is not the case anymore.

3) The strategy was also based on a specific pattern for matching year-round variations in herd needs (linked to the herd production and sales pattern) and in forage resource availability. This strategy is different from the current common conception in long term use in animal science. These matching principles also included other and less recognized matching practices based on physiological aptitudes of local bred animals to meet by themselves variations in feed availability without significantly hampering their production (long time neglected by mainstream animal science), such as, the aptitude to mobilize and recover body reserves, the compensatory growth phenomenon, etc... In particular, the survival of the breeding female in the face of very harsh and variable conditions was a priority. If the local species are always dominants in the communities for their resistance and resilience capacity during drought period, there is, however, an increasing part of the Algerian sheep species (called Queue Fine) in the Tunisian community to respond to consumption demand.

4) Managing without resorting to external and costly inputs despite climatic uncertainty was also an important objective in traditional production patterns. The farmers considered normal the variation between years in the annual level of herd products (within a given range), and at the same time, they prioritised flexibility as the major quality for their bio-technical system. This quality was gained partly from the multiplicity of animal product types that helped limiting the consequence of bad seasons on system operation, but also, from specific herd management practices that contributed to fulfil this objective. However, the observations collected in autumn and winter 2002 showed that, today farmers buy straw at full price which is comparable to grain price. With the development of cereal crops, farmers gave up goats that demand too much time of supervision to avoid damages to the crop.

The heterogeneity of production patterns among animals and throughout the year constituted a key factor of resilience in harsh environment. The capacity to maintain a flexible but suitable timeliness during a long life-time span and life-time performance was also the main traditional farmer criteria with respect to individual performance. Today, these mechanisms are less consistent and farmers develop a short time management of the flock: (i) the cereal or by-products stocks do not cover more than one year and, besides, few farmers can stock during periods of low price; (ii) fattening activity is developing and reproductive activities are abandoned by some farmers; and (iii) opportunistic feeding strategies to benefit from the available resource. These changes imply a more short term dependence on market and economic risk, without reducing climatic risk.

A major common trait in farmer strategies in harsh environments appears to be the variety in the risk-coping practices within the same farm in order to support the huge inter-annual variations in climatic conditions and to face droughty years to enable system survival. These include regulations at the

livestock unit *per se*, such as selling part of their livestock, herd seasonal migration, but also, at the higher levels in the family-farm organization and operation.

Understanding whole-farm operations as short and long term herd management decisions stresses the need to account for the closed relationships between cropping systems and livestock systems. In agro-pastoral systems, the diversification through agriculture is a well recognized way to produce feed for livestock –as a common strategy to reduce climatic risk and compensate natural resource variation-, but also, to provide seasonal cash flow and to cover family food requirement. In the Maghreb, the main cropping system is a rotation of barley for animal feed and durum or bread wheat for human food consumption. During favourable/good years, the farmers produces feed and food stock for the next 2 to 3 years, a condition for the global reproducability of the system at long term, but also, the crops may be grazed green in winter before stem elongation, then, allowed to mature for harvest. However, if the year is mitigated, the total standing crop may be grazed at maturity because low yields do not justify harvesting (Nordblom et al., 1997). In drought conditions, the majority of farmers attempt to maintain their herds owing to feed reserve (cactus, barley grain stock) and subsidized feed at low price (most of the time, barley grain). Agro-pastoralists fine-tune their production system with perennial crops, such as fruit trees (olive or almond tree) in order to share risk over at least 4 years: (1) the olive production depends on the last year climatic conditions and produces olives, for self consumption or market, and leaves and twigs from pruning for the animals, (2) cereal production depends on climatic condition of the current year and it procures feed stock for the next 2-3 years, and (3) animal production could be improved the following year and farmers put into play the resilient capacity of local bred (Elloumi et al., 1991). Alternative resources, such as *Cactus, Atriplex, Acacias*, present resistance to dry conditions and they constitute important innovations in these systems (Bounejmate et al, 2001). So it is hardly possible to understand the efficiency of the production system over one year, and herd management is only one component of the global long term farming management.

The household systems may also associate traditional system and intensive livestock systems based on fattening. These two systems are articulated: the intensive system is possible owing to the cash flow entries from the traditional systems. Similarly, the extensive system benefits from the higher income in the intensive one to ensure its reproducibility.

Another characteristic of the traditional system in harsh environments is the diversification in off-farm activities. In the Tunisian community, 82% of farmers benefit from emigration revenues or commercial activities that represent 37% of the total farm income in 1999[3]. Wage labor and self-employment in off-farm activities may be considered as risk absorption strategy during times of stress rather than profit maximization. The incomes may be reinvested in the livestock system, mainly to increase the live asset considered as the main savings asset. However, the off-farm diversification depends on many factors, such as, farm size, social capital, employment opportunities for men and women, and cultural factor.

More generally, at the farm level, the division of labor, the intra household decision making and organization, the control over assets at the livestock system, the off-farm opportunities and their evolution due to family or external factors are as important as herd management in order to understand the resilience of the "whole farming system".

Furthermore, understanding the strategies at the farm-level and their changes need to consider a wider system (of a "multi-agent" type) issuing from the traditional social organization of the communities. In pastoral societies, the risk management strategies are mainly established at the levels of extended family and community (Balent and Stafford Smith, 1993; Swallow, 1994 ; Park, 1993), and include many forms: (1) group insurance mechanism, including group inheritance of livestock to ensure inter-generation and inter-household sharing asset; (2) sharing of food and hospitality: household suffering prolonged stress may rely on family members, not subjected to the same stress (Scoones et al., 1996); (3) livestock tenancy arrangements with different forms of agreement; (4) community credit societies to fund agricultural assets; and (5) combination of collective and individual property rights on pastureland with different levels of social organization (group, village, community, region).

[3] Result from a survey near 39 households in Zoghmar (Sidi Bouzid), The Mashreq/Maghreb Project , ICARDA.

The trends observed in the Maghreb emphasize the pressure from economical, institutional and political environment (such as, land privatization, drought mitigation policies, etc...) on the lifetime changes in the farming systems. This pressure has led to disorganized risk coping strategies and threatened the long term sustainability of the natural resources. The weakening of traditional modes of regulation in the use of collective pasture appeared to be an important factor that contributed to such evolution: it encouraged "individualist" behaviors and carelessness in the land resource sustainability (Balent et al., 1992; Chaherli et al., 1997). Therefore, if the main key factors of sustainability of these systems were linked to the adaptation and flexibility of farm-household strategies to the climatic conditions with acceptance of deviation from the technical optimum. Currently the evolution of the farming system in these areas is linked to: (1) the capacity to develop risk absorption strategies at the household levels, and (2) the institutional and social changes at an upper level of organization of the agricultural systems.

3.2. Inter- and intra-community factors of similarities and differences

The analysis of the inter- and intra-community factors of similarities and differences resulted from multi-factorial analysis based on different sub-systems of the farm. The clusters of farmers are deduced from this factorial analysis for each community (Annex 1).

In the three communities, it is worth mentioning the discriminating role of the livestock activity. In Morocco and Algeria, two types are distinguished: (1) the farmers who abandoned the livestock activity during the last drought, and (2) the farmers who maintained it. Among the first ones, both small and old farms are well represented. In Tunisia, there is an opposition between old agro – pastoralists and the young farmers in terms of systems diversification.

The second common factor among the communities is the small relation between the land capital and flock size. Each community counts large herders with more than 60 ewes and less than 5 ha of agricultural land. This disconnection is more important in the Moroccan community that benefits from common rangeland. In the Tunisian community, however, the integration between cropping and livestock activities is more developed. In the Algerian community, the relations are more important between cactus plantation and livestock. These elements put in evidence three pillars of the livestock activities: (1) the common range in Ait Ammar (Morocco), (2) the cactus in Sidi Frejd (Algeria), and (3) the cropping system in Zoghmar (Tunisia).

Moreover, we noted close relationships between the livestock system and the family composition and history. In the Algerian community, cropping activity seems to be the domain of the Mejène social fraction, although, livestock activity concerns mainly the Chegaga fraction. In Morocco, this differentiation goes back to the history of the community. The Osimba fraction was put in the less fertile zones of the community. The cropping system is, therefore, limited to cover the needs for self-consumption, although, they use the rangeland for grazing which help developing livestock activity.

For the three communities, then, structural factors (land and flock size) constitute the main discriminating ones. But, in Tunisia, these factors are more important due to the presence of off-farm activity. These off-farm activities, contrary to Algerian and Moroccan communities, participate actively in agricultural funding. All the farms that have access to off-farm income of more than 8000 DT per year, count more than 100 heads in their flock.

Clustering analysis identified 6 types of farms in Sidi Fredj, 7 in Ait Ammar and 6 in Zoghmar (Annex 1). Four types of farm are very common to the three communities:

1. The large agro-pastoral farming system with more than 60 ewes in Zoghmar, 30 in Sidi Frejd and 25 in Ait Ammar.
2. The mixed farming systems on less than 10 ha land and with a medium flock size (between 10 and 20 heads).
3. The old farms (without expected inheritance) most of them abandoned or reduced the livestock activity after the last droughts (1998-2002)
4. The farms close to the threshold of survival are mainly young farms with little land and no land status.

There are other types that are specific for each community.

- In Algeria, there is a non stable type of farms that is in the process of stocking animals.
- In Morocco, the group of "Tmourira" is a specific type of farms that are residents in the common rangeland and are mainly sheepherders.
- In Tunisia, there are two other types: the multi-active type that combines an administrative activity and the farmers with irrigation.

4. Analysis of the farmers' marketing strategies and meat channel

4.1. A brief presentation of meat sector in the Maghreb

Small ruminant activities constitute the main livestock sector, representing more than 90% of the total ruminant cattle (the sheep representing 73% and the goat 17% in 2003) (FAOSTAT, 2004).

For the period ranging from 1961 to 2003, an increase of sheep flock of 246% in Algeria, 28% in Morocco and 33 % in Tunisia was recorded. The goat flock increased by 154% in Tunisia and 64% in Algeria. But, in Morocco, goat' stock decreased (25%). In general, the small ruminants (SR) stock in the Maghreb registered an increase of 55.3%; the total number went from 32.64 millions of heads in 1961 to more than 50.7 millions in 2003. This increase is not regular and it shows various trajectories according to the country. Algeria, for instance, experienced very favorable years during the seventies and eighties, and also, different policies (subsidies, credit, Green Revolution) facilitated animal stocking. Today, with the reduction of subsidies (especially on feed), the development of clandestine and illegal transactions with Tunisia and the credit constraint highly limit this increase. In Morocco, the variations of animal stock are well correlated to climatic conditions.

Table 3 shows a good adequacy between production and demand since the 1960's. These official data, however, hide a more complex reality. First, the total consumption of meat in North Africa ranges between 18.1 and 25.5 kg/person/year, against 90-110 kg in the North Mediterranean (Table 4). The consumption of SR meat registered a decrease in the total meat consumption for the benefit of poultry meat. Apart from Muslim ceremonies, various studies showed that the consumption of SR meat remained as an expensive treat. In Morocco, the elasticity coefficient of consumption of red meat is around 1.03, until 1.12 in rural area.

Even though the meat market is declared free in the three countries, there are important rules and arrangements to control the international exchanges, such as, public or private monopolies and border taxes. Moreover, the official data on import and export does not take into account the clandestine broader exchanges in the sub-region. The border illegal market is estimated to 1.8 million heads, mainly from Algeria to Morocco and Tunisia. These fluxes are partially controlled by authorities according to the supply and demand in the country. Between Algeria and Tunisia, this informal market is quite specialized with the production of lambs in Algeria and stored or fattened sheep in Tunisia. Therefore, self sufficiency in red meat, especially for SR, should be analyzed at the regional level. But, these fluxes do not seem to reduce the price fluctuations, especially, during the high demand of Aïd El Kebir. The absence of mechanisms of regulations favours speculative behaviours at different scales, from the producer to the final consumer.

Therefore, there are three factors that influence this sector: (1) the climatic conditions, (2) the seasonality of the demand according to Muslim ceremonies, and (3) the agricultural policies, such as, the drought mitigation policies. The climatic risk and the impact of the drought on the flock management are well described in the literature. But, few research studies attempted to approach the meat channel as a social organization with interactions between agents. Today, some farmers are developing fattening activities to satisfy the Aïd El Kebir demand. The market conditions orient farmers' strategies. With the liberalization, the demand could change due to prices' fluctuations. But, during Aïd El kebir, the demand seems less rational. The qualitative studies conducted in the project permitted approaching some changes in the red meat channel that influence farmers' behaviors.

4.2 Compared approach of meat channel in the three countries

The results of the analysis for each country case study are reported in the French report (Alary et al., 2004). Here we mainly focus on common and specific points.

4.2.1 Three distribution channels for the sheep meat

The sheep meat uses three main distribution channels in the three countries (Table 5):

1. Farm slaughtering for the enlarged family self consumption

This way of doing concerns mainly the old female animals that cannot be marketed. This represents around 15 to 20% of the total consumption.

2. The sacrifice of young male animals for Aïd El Kebir or family occasion (marriage, birth, etc...)

This way concerns about half of the animals, mainly male animals (more than 12 months), sold during a period of one week. The lambs are fattened either at the same place of birth or at another place. A network of traders manages the deferment and forwards the animals to the main places of consumption (urban areas). These animals are the most profitable. In Morocco, the price reaches the equivalent of 75 to 80 Dh/Kg per carcass; this is 30% more expensive than the usual price. In Tunisia, the plus-value reaches 15%. These plus-values are the most profitable to the traders or the farmers who practice the fattening.

The fattening and marketing activities during Aïd El Kebir need an important practical knowledge and a source of funding for several months (between 6 to 8 months) to immobilize the live capital (lambs) plus the expenditure in feed. The small herders are generally forced to sell their lambs earlier in order to have sufficient cash flow to provide feeds for the reproductive flock, and sometimes, to cover social needs. For these groups, a system of credit similar to that for the cropping season should be put in place. These farmers need supports for organizing the transport and selling activities around the towns, as it is practiced by traders. Today, many farmers are reluctant to go to the urban markets because of the extremely bad conditions in the *souks*. The high margin observed in Tunisia in the distribution channel may be considered in the transaction costs due to the risks of robbery, the cost of sheep keeping, the cost of accommodation, etc...

3) Regular supply of households

This distributional channel concerns the animals slaughtered in the rural or urban abattoirs, and marketed through the butchers to the consumers, restaurants or collectives This represents 30 to 40% of the total consumption of red meat. Two circuits may be distinguished:

Short channel: in the rural abattoirs close to the souks, the butchers slaughter the purchased animals. The animals come from local herders, but, they are provided either by the herders themselves or the traders, or by the herders specialized in the fattening activities.

Long channel: The animals for the urban consumption are slaughtered in the urban abattoirs. The actors are wholesale butchery traders who provide the urban butchers. These traders receive the animals from different regions of the country according to the season and the demand. They buy the animals alive and sell the carcass, the offal and the skin. The price of the offal and skin reimburse the transportation cost and the slaughtering cost. The sale price of the whole carcass at the butchery is often inferior to the purchase price of the live animals.

For the majority of animals, the traders practice themselves the fattening activities or make the animals fattened under their control. According to interviews, the margin from the fattening activity is on average shared between the trader and the supplier (herder).

Therefore, between the herder and the urban butcher, two intermediaries intervene: the first one to buy the animal at the herder and the second to sell to the butchers. Sometimes, the animals can be sold several times. The comfortable herders sell their animals after fattening. But, the small herders or herders in difficulty sell their low-fat animals that are purchased by largest herders.

4.2.2 Preponderance of male production for Aïd El Kebir and development of the fattening

For the three countries, the majority of young male animals are kept for the sacrifice of Aïd El Kebir or for the celebration of family events (marriage, return of one member of the family). The increasing demand (related to the demography) and the occurrence of successive drought periods during the last decades explain, then, the stability of the total animal stock and the low increase in productivity. All the productive sheep systems (from husbandry to marketing) are oriented towards male production for Aïd El Kebir. On the basis of national statistics in 2003, only Algeria registered insufficient number

of lambs for Aïd El Kebir, because of the border exchanges that were estimated to more than 500 thousand heads.

The main destination of male lambs to the sacrifice is correlated to the development of the fattening practice of animals, very often, in a farm other than the one of birth of the lambs. We also noted a sort of specialization in the activities. For example, in Tunisia, following the 5 years of drought, the farmers in the community increased the number of fattened lambs in the farm. These lambs came from the northern part of Tunisia where the drought was less severe or from Algeria. This explains the large diffusion of Algerian species in Tunisia.

This implies a differentiation in the farming systems according to their capital. In Tunisia, the typology according to marketing strategies reveals 4 main groups:

1. «The group of farmers who practice a short term fattening». These farmers buy their animals at the age of 6 to 8 months and fatten them for less than 3 months, just before Aïd El Kebir. The lambs born in the farm are kept to adjust the cash flow during the year. The feeding system is based on local resource.
2. «The group of farmers who practice long term fattening». This group gathers farmers who have more than 20 ha of land. The lambs, less than 6 months old, are bought just after Aid El Kebir and will be sold during the next Aid after 7 to 8 months of fattening. These farmers attempt to fit to the demand. For example, some farmers in the community have changed the race. The lambs born in the farm are used mainly to fund the feed supply for the fattened lambs.
3. «Group of herders who fatten the animals born in the farm». This group gathers agro-pastoralists with more than 50 ewes. In this group, around 83% of the fattened lambs are sold during Ramadan (34.9%) and Aïd El Kebir (48.1%).
4. "Group of treasurers». These herders have less than 18 ewes. They do not have the capital (own or credit) to buy lambs for fattening. So, they practice traditional husbandry with repartition of sales during the year.

In Morocco, the fattening activities concern mainly experienced farmers in the agricultural areas of the community (Osibra fraction). In Algeria, the last droughts (1999-2002) affected all the farmers, and today, we observe few fattening strategies. The majority of these farmers are, now, in the phase of live re-stocking. This example shows that specialization in the fattening is changing according to the climatic conditions.

The farmers who practice themselves the fattening attempt to sell by themselves the animals in the large towns (Tunis in Tunisia or Tanger and Rabat in Morocco) with all the risks encountered (rubbery' risks, transportation costs, etc.). In the Moroccan community, the large farmers have developed closed relations with the traders; the number of traders from other regions explains the dynamism of the local markets and also constitutes an indicator for the period of selling.

4.2.3 Market almost perfect and price formation

Livestock markets (souks) are numerous in each country and they are open to all, for a modest entry tax. Free entry is almost ensured. These markets are open to the herders, even if they do not have animals for selling. The transactions are public. Information on the prices is well-known by all. Moreover, the traders who work in different markets make comparisons for the farmers. The products are quite homogeneous and, up to now, there is no segmentation of the market according to the characteristics of the product. In these markets, the actors (buyer and seller) are numerous. In the large markets, there are several hundred traders. Any actor can significantly influence the market.

Free entry, transparency, homogeneity, atomicity of the demand and supply: the four conditions of pure and perfect concurrence are there. If this system allows providing the product at lower cost from the producer to the consumer, there is also a rapid transmission and adaptation of prices to unforeseen turn of events. The absence of regulation reinforces the variability of prices.

The high fluctuations of observed prices in the market are mainly due to erratic climatic conditions that induce an increase or decrease of products' price, a decrease or increase of feeds in good or bad rainy conditions, respectively. Besides, the predictable events, such as, the increasing demand during Aïd El Kebir and Ramadan, are anticipated by the actors and the increase of prices is limited by the

increase of the supply. On the other hand, the low margins do not allow the accumulation of funds for future investments (development of new products, improvement of the productivity).

The sale price in the souk is quite well known at the time and it does not vary according to the quality. For example, in Morocco, the carcass price is around 935 DH for a lamb of 17 kg; it is sold after at 55 DH/kg to the last buyer of the live animal. The skin, the head and the offal constitute the charges and the wage of the person in charge of the slaughtering. But, we observe some gaps between the expected price and the maximum price that the traders are willing to pay. This margin varies with the searched model of lambs; in Tunisia, this margin of negotiation is around 34 DT for traders with no preference to 67 DT for traders who are looking for the local race. This underlines the margin of negotiation for the farmers between the first price proposed by the trader and the price that the farmer could expect. Table 6 shows the difference between expected margins in the urban and rural markets.

The income of the wholesale butchery traders (purchasing of the animal, slaughtering and selling the carcass) are quite low, around 2% of the carcass price. Without weighting the animals, the buyers take always the risk to pay more if there is an under-estimation of the weight or may be blamed if there is an over-estimation. Generally, this risk is low because of the great experience of these traders who work mostly in the same areas and same production systems. In the other hands, the high concurrency excludes the systematic under-estimation on the weight of animals.

The butcher may get more important margins at the time of selling meat retails, according to the piece of meat, the season, and the place of sales. But, the size of business is generally small, less than one hundred kg per week.

If the last sale price for live animals is with no surprise, it is no the case for the producer sale price for at least two reasons:

- The herder is never sure to find a buyer when the animals are ready for market. If he cannot sell at appropriate time, the animal generally loses its value (due to age, fat content, end of the ceremonies) and it will cost more for its husbandry beyond the optimal moment of selling;
- Sometimes, the herder is obliged to sell his animal before the end of the fattening period because of lack of resource or need of money for urgent social events.

Moreover, the herders who are in charge to produce lambs for fattening feel often misled, and they have the impression to be the loser of the channel.

The herders who are in charge of the fattening are often traders or butchers at the same time with some formal or informal contract with the person in charge of the slaughtering. This high speculative activity can provide important margins with a good expected price on feeds and a good local experience on the purchase of low fat animals. Except for Aïd El Kebir, the expected price for ended animals is not a source of margin due to the low variations. But, the preservation of this fattening activity needs some conditions, either the vertical integration with some more or less fixed modalities or good marketing conditions such as in the Khouribga region (Morocco), which is not the case for remote areas.

4.2.4 Characteristics of traders

Most of the transactions on live animals (low-fat or fattened) or red meat are realized by plenty of intermediaries with a small business (no more than one hundred animals per year). The traders who buy animals to herders are generally themselves small herders who want to complete their income or want to rebuild their flock.

If livestock activities (husbandry, fattening, and trading, slaughtering, retail selling) are well defined, the actors may combine different operations according to their capital (flock and credit), the climatic conditions, and the social needs.

Few intermediaries of large scale act at the national level and they generally benefit of good information throughout the channel. But, their business does not affect the adjustment between the demand and supply. At the opposite, they can accelerate the establishment of segmentation in the market in the first steps.

4.2.5 Change of consumption' practices and distributional channel

The red meat is traditionally consumed stewed, i.e., for a long and humid cooking time. Nowadays, the roasted leg of lamb becomes frequent in wealthy families, as well as, grilled meat in the restaurants. These preparations require nice tender pieces and younger animals. The tenderness varies according to carcass pieces which explain the fine type of cut by butchers. In this regard, the size of carcass which determines the leg of the lamb, the age and the tenderness are the new criteria of quality for both the consumers and the retailers.

The traditional type of cut does not take into account the distinction between the different parts of the carcass. Now, the type of cut is more anatomic with the distinction between the leg, the chop, the shoulder, the brisket, etc. according to cooking practices. There is also a distinction of prices between these different pieces. The grilled pieces can be sold from 10% (popular markets) to 30% (well-to-do markets) more expensive.

Therefore, we observe a differentiation of price according to the markets, the types of consumers, the social events, the seasons and the distribution channel. In Tunisia, the origin of the lamb and the race are becoming a criterion.

The traditional supply to urban areas consisted of the transport of live animals to urban markets, slaughtering in urban abattoirs, and delivery of the whole carcass to the butchers. Nowadays, the new practices of consumption induce some changes.

In wealthy or high-standard urban quarters, the butchers sell more legs of lambs than stewed pieces. In the opposite, in popular quarters, the butchers who have bought the whole carcass sell the legs of lamb at the same price as stewed meat. In the retail places (butchery, supermarkets, restaurants), there is a demand for differentiated pieces of meat in a proportion different of the carcass. Some retailers have different selling points in the town. They can distribute the different meat pieces according to the demand and, by doing so, they can enhance the value of each piece.

Moreover, since the mid-1990's, important super markets were developed in the Maghreb countries. The meat departments of these super markets registered important success and, in Morocco and Tunisia, the demand is high. Some super markets developed free department with packed meat pieces.

This new type of retail selling may change the distribution channel; the retailer could establish his enterprise of cutting and packaging out of the urban areas. But, the main obstacle is the abattoir because they need to have a sanitary document and ensure the payment of tax.

Therefore, two changes appear in the meat channel: (1) the meat channel instead of the live animal channel from the production regions to the regions of consumption; (2) the supply of retailers in meat piece and not the whole carcass.

Important changes are then induced for the traders in charge of the slaughtering in the urban areas. Until now, they receive live animals, low-fat or fattened, and sell the carcasses to the urban retailers. Their profit comes from the supply management and their local experience in fattening. Now, they need to start specializing in selling meat pieces. Their profit will then come from the capacity to adjust the prices to the different pieces of carcass according to the destination.

In rural areas, new intermediaries will buy the live animals and sell the carcass to different wholesalers. Their profit will come from the management of the supply, their knowledge of fattening, and their capacity to adapt the different carcass to the different types of demands according to the season. The criteria of selling also change in the rural areas with new demand according to the race, the colour, the weight and the anatomical structure.

4.2.6 Implications of border trade for the Algerian community

In the wilaya of Souk Ahras (that covers Sidi Fredj community), the main sheep markets are: Sedrata and Mdaourouch. In the periphery, the most important sheep markets are: Chéria and Tebessa in the Wilaya of Tebessa, and Meskiana in the Wilaya of Oum El Bouaghi. The importance of these markets is mainly explained by the proximity to the border and the speculative activities. But, within the community, a large proportion of the sales are always door-to-door sales in order to reduce the transaction costs such as transport, access to the souk and official controls in the roads.

In order to reduce the clandestine market of live animals towards Tunisia, the Algerian authorities have established a decree of the Wilaya that regulates and restricts the transport of live animals to three animals. If the herder wants to transport more than that, he must require a custom authorization. Every week, the herder must introduce his professional card to the customers and declare the marketed animals. Without authorization, the herders are obliged to subcontract with other farmers and pay a supplement.

Obviously, different mechanisms to overpass these regulations were developed. The herders sell their animals that they declare to the customs, renew them in the market, and then, declare them as unsold. Other herders declare a number of animals that they do not bring to the market, and buy the same number. These animals, declared in double, are then sold in the Tunisian market.

Between the sale in the souk and door-to-door sale, the choice is easy because of the speculative trend in the souk. But, the problem of transport limits selling in the souks. In Sidi fredj community, the majority of herders buy their live animals in Ouenza market (located at 10 km from the community). Only 1 or 2 purchases in the souks of Tebessa, Taoura, Chrea and Merahna were recorded, mainly due to friendly relationships between the herders and the traders. In Sidi Fredj, 50.6% of the 221 animals bought between autumn 2002 and summer 2003 were young females or ewes. In fact, the majority of the herders were in the phase of re-stocking following the last droughts (1998-2002). Besides, 71% of the 243 live animals sold were young males, with less than 12 months old, and 20.1% were more than 12 months old. These sales were due to the urgent need of cash for re-stocking. Due to its proximity, two third were sold in Ouenza market. Table 7 summarizes information about the purchase and sale prices by the farmers of Sidi fredj.

For the 23 herders, only 3 of them sold to familiar traders. The main selling criteria are the price and the cash, and for purchasing the criteria is the knowledge of the person. The herders provide the young lambs that are easily sold in the Tunisian market in spring and summer.

Among the farmers, 69% of them declared to be well informed about the purchase prices and 95% on the sale prices. Besides, 95% compared the prices between the different souks before making a decision. Information on the prices came both from the souks (60% of farmers) and from the community (30% of farmers). Meanwhile, in making the decision to sell, the prices intervened only by 36% while the urgent need of money explained 54%.

Although, 90% of herders declared that cash payment is the main criteria in selling operations, 22% accept credit sales for 2 to 4 weeks. Also, one third preferred an advance with 10% increase on the price, and two third preferred to be paid at once with no report and with 10% reduction on the price. This underlines farmers' suspicion towards traders. Moreover, there is the uncertainty on the weight of animals, and according to farmers, the traders under-estimate the weigh within a range of 1 to 9 kg.

The number of live animals sales serves for re-stoking for the groups 5 and 6, and for covering social needs for groups 2 and 3 (annex 1).

In this region, the final decision on the market goes back to the highest bidder: Algerian or Tunisian. The Tunisian demand influences the sale's price and constitutes the main market opportunity.

To ensure selling, the agents practice credit sales for the Tunisian market. Some credits reach more than 2 millions DA. This amount gives information about the importance of animal trade across this border. Moreover, the agents are reimbursed in euro and benefit from the rate of exchange.

In the majority of cases, the Tunisian traders visit the different Algerian markets, choose the animals, and buy them through an Algerian trader. The animals are gathered in a place closed to the border and, at night, they cross the border. In Sidi Fredj community, the border exchanges concern, mainly, the lambs of 6 months, although, in the South of Tebessa, some transactions concern ewe as well. The lambs are generally bought to be fattened. This explains the high proportion of the Algerian race (called *Queue Fine*) in the border regions of Tunisia.

Tables 8 and 9 show different purchasing and selling prices in Algeria and Tunisia according to the rate of exchange. Comparison of the two tables shows the importance of exchange with the informal rate of exchange. For example, a male more than 12 months can be sold 16-18000 DA on the Algerian market and 24000 on the Tunisian market due to the informal rate of exchange. But, the re-stocking in

Algeria explains the high increase in sheep prices and this can limit the exchanges in the next two or three years. Moreover, the prices are producer's prices and the border exchanges depend on traders. Finally, the exchanges are more complex if we integrate the exchanges in kind between the two countries.

4.3 Implications of the marketing channel on technology adoption

The analysis of the sheep market showed the following common points:

1. The channel is quite short with only 2-3 intermediaries between the farmers and the final buyers; this explains the good information on the prices.
2. The high price of sheep meat. This might be explained by different factors among which: (i) The production is not much flexible and depends mainly on the climatic factors; (ii) the natural protection of the national markets due to the preference of live and local lambs for ceremonies, such as, Aïd El Kebir; (iii) the control of the importations.
3. There is a closed relationship between the average price of the lamb for Aïd El Kebir and the average monthly wage in the country (table 10).
4. Good information on the prices due to frequent trips to the souks and the mobile phone that helps getting information on distant markets. Moreover, the majority of herders are small ones compared to the past decades when there were larger herders with more than 1000 heads. So now, the risk of cooperation is minor. Finally, a great part of the marketing is controlled by the farmers during Aïd El Kebir and they can travel for long distances.
5. But, if the farmers have good information, a certain variability of prices due to the negotiation process between the farmers and the trader is observed. Moreover, during Aïd El Kebir, the uncertainty remains on the determination of the day with the highest prices. Generally, during this period, the prices increase progressively as Aïd El Kebir gets closer; but, during the last week prior to Aïd El Kebir, the prices may continue to increase or may decrease a little. The determination of the date when the prices fall is really uncertain. There are apparently no definite rules.

The differences between the three communities are mainly due to the localization of the community in the country. For example, the particular situation of Sidi Fredj in Algeria (which is close to the border) creates some speculative phenomena. For the Zoghrmar community in Tunisia, the farmers can sell their animals directly in Tunis because of the small distance to the capital.

According to the farmers, the sheep market is functioning quite well and it does not constitute an obstacle for technology adoption. Also, the good prices should favor investments in technological improvement. But, the main source of price variability is mainly due to the prevailing climatic conditions. Faced to this, it appears that only institutional arrangements could help the farmers to invest in new productive systems. (Table 10)

5. Cactus innovation, risk and market

5.1 Cactus adoption in the Tunisian community: risk and market

The risk has long been considered as an important factor that reduces technological adoption (Rosenberg, 1976; Lindner et al., 1987; Just and Zilberman, 1983; Marra, 2001). In the literature, two approaches have been developed: 1) the first one focuses on the investment decisions in an uncertain environment; and 2) the second explores the linkages between the risk induced by the technology and the risk attitude of farmers. We propose to test these two approaches on the technology of spineless cactus in alley cropping.

This technology was developed in Tunisia in the mid-nineties within the framework of the M&M research project (ICARDA) in collaboration with INRAT and the Office of Livestock and Pastureland (OEP). It consists on planting rows of cactus 20 m wide; the inter-rows may be cropped with cereals or left as fallow for grazing. The main expected outputs of this technique are: the increase of annual biomass in the inter-rows; the limitation of run-off and erosion; and the production of feed stock (cactus pad). Agronomic trials conducted in 2004 in the SPIA/ICARDA Project in a restrictive number of plots showed that barley biomass increased from 4.24 t/ha to 6.65 t/ha and grain yield from 0.82 t/ha to 2.32 t/ha with a maximum of 7.6 t/ha in cactus alley cropping compared to the control with no cactus plants.

The experimental data collected by INRAT shows that cactus pads constitute a low-cost feed for animals and help by-pass dry years. An exhaustive survey conducted in the community in 2002 showed that cactus consumption reduces the feed cost per head by 13.2%. Between 1995 and 2002 among which 5 years were dry, the live capital was reduced by 32%, instead of 40.5% for the farmers who did not use cactus.

Soil analysis revealed a significant increase of organic matter, carbon and phosphorus being 350%, 450%, and 100%, respectively, in the non cultivated land. Cereal cropping in this system could profit from these nutrients, and this could explain the increase of barley grain. These first elements confirm the importance of the technology from an economic, agronomic and environmental point of view.

At the community level, just two years after the introduction of the technology, the rate of adoption and the degree of adoption in 2002 reached 30.6% and 29.7%, respectively. If these indicators were calculated according to land or live capital, important differences among farmers were observed. The average area allocated to the technology varied from 1.54 ha for the small farms (less than 5 ha) to 9.9 ha for the large farms (more than 15 ha). The rate and degree of adoption were, 61.3% and 43.22% for the large ones and 13% and 14.5% for the small ones. Similarly, the rate and degree of adoption were, respectively, 46.1% and 36.8% for the large herders (more than 50 heads of SR) and 25.8% and 22.6% for the small ones (less than 15 heads).

To explain these gaps, one hypothesis could be that small herders are reluctant to make investment decisions, although, the short term management of the farm is difficult. Moreover, the small farmers would be more risk adverse. Three scenarios were tested:

(C1) Increase of the planning horizon from 5 to 10 years

(C2) Decrease of risk aversion by 20% for all farm types

(C3) Increase of risk aversion coefficient by 20% for all farm types

The results are reported in Table 11 and 12.

Firstly, it is noted that with the lengthening of the planning horizon from 5 to 10 years, all the farmers extend the technology. The area with the technology doubled for the agro-pastoralists (EA1) and for the mixed farming systems with irrigation (EI2). For the small dry farms (EA3) and the diversified farms (EA2), the area increased by 16.5% and 5%, respectively. For other scenarios, there were no changes in the rate of adoption, except, for the farm type (EI2) for which the area increased by 21%.

At the same time, live capital increased. If the majority of investment in the technology were realized by farmers without irrigation (EA1, EA2, EA3), the animals capital increase concerned in majority the farms with irrigation (EI1, EI2, and EI3). The new cactus plantations induced a new allocation of land: the agro-pastoralists allocate now two-third of their cereal area to barley, against 43% before, and the small herders (EA2 and EA3) who allocated 90% of their cereal area to barley are sharing the area now between barley and wheat. If a reduction of the annual cash flow in the first five years of the planning horizon is observed, a decrease of the feed cost (by 11.30 and 5.6% for EA2 and EA3, respectively) is experienced by the small farmers. Besides, a reduction of the community inequity is observed; the Gini coefficient decreases from 0.33 to 0.28 in average on the planning horizon.

Knowing that in reality, farmers have not increased their area with the technology, these results show that the main obstacle to adoption is the management decision-period of the farmers. Most of them have problems of cash flow at short term and their management does not exceed for over a year. In this context, only the funding of the technology or the establishment of a credit system could favour the adoption of the technology.

The reduction of the coefficient of risk aversion favors the stocking of live animals for large and medium farms oriented to livestock (EA1 and EA2). These farms register a decrease of cash flow mainly due to the increase of feed expenditure. Conversely, the increase of coefficient of risk aversion induces a great de-stocking in live animals for the same farms. This shows that the agro-pastoralists and mixed systems without irrigation are the most sensitive to risk and they regulate their livestock accordingly. On the other hand, the small farms (EA3), close to the threshold of survival, have a very short room to manoeuvre and they do not react to risk.

Beyond this information, the cactus plantation, as perennial crop, is in keeping i with the long term view of the farm. Nowadays, with the new tendencies, the farmers are more dependants on purchased feed for the short term. This constitutes an obstacle to the adoption of long term technology.

Next, the impact of the institutional actions, especially, the subsidies and the technical support to implement the technology are evaluated. In the simulations S1 and S2, farmers are supposed to have access to the technology without any support. Two levels of expected yield are assumed: (S1) the expected yield remains unchanged; and (S2) a 30% increase of cereal yields[4]. In the second step, the institutional support that covers the pads' purchase, the costs of implementation and the subsidies is introduced. The simulations S3 and S4 are, respectively, without and with cereal yield increase. The subsidies are distributed for the first 3 years of plantation. The support is limited according to livestock and the area for each farm type. In (S5), there is no restriction on OEP support. Table 13 shows results of the different levels of adoption of the technology with and without subsidies.

Three groups of farmers invest in the technology in S1 (with no yield change). Firstly, it is important to note that the group EI1 is the only one that does not have spine cactus plantation in the farm. This group represents also the more comfortable group in our sample with a secure off-farm activity in the administration and 4 ha in the irrigated perimeter. The high level of adoption observed confirms the previous result that irrigation is a determinant factor for adoption. The group EI2 also invests in the technology by opposition to the reality. This difference between the reality and the simulation may be explained by two factors:

1. The farmers are reluctant to implement the technology by themselves knowing that they can receive subsidies.
2. The information about the technology. Some farmers declare that nobody introduced them to the technology, although, they have seen the new plantations of cactus. They are not aware about the yield increase' expectations, especially, for farmers having a small flock size.

In S2, all the farm types adopted the technology. We can observe the similitude of plantation areas for the large farmers (EA1 and EI1) between the simulations and the observations (Table 7). This can be explained by the important power of negotiation of these farm types (flock size, good management, etc...) to plant what they want, compared to small farmers. However, these results may suggest that without subsidies but with good information about the productivity gains, farmers may implement the technology in the majority of marginal cereal lands.

In S3, the OEP support is limited for each farm according to flock size. Only the farm type (EI2) implements the technology without the subsidies, and the group EA3 plants 1.34 ha more with the technology and without any subsidies. With the expected increase of cereal yield, all the farmers implement more than the subsidized area and fund the rest by themselves.

In S5, all the farmers increase the acreage for spineless cactus in alley cropping by three folds, compared to the baseline scenario. The results show the importance of the technology with financial support. But, the similitude between S4 and S5 shows that good information about yield expectations with the technology ought to have the same importance than subsidies. It is true that the reality is more complex:

1. The expected subsidies can be more crucial; especially, during dry years, and the expected yield of cereal in alley cropping could be inferior to the subsidies.
2. Why implement this technology by himself if one could profit from subsidies and yield increase in the same time? So some farmers are waiting.
3. Good information at the community level is always difficult or even impossible
4. Personal perception about the information is more important in the farmers' decision process than given information about the technologies.

Finally, in a new set of simulations, the opportunity to sell the pads' production either at the community level (C5) or at the national level (C6) was introduced. We suppose that the national

[4] The cereal yields estimated from on farm trials in 2004 are the first measurements of the expected cereal yields with the technology in Tunisia and will serve as reference in this study.

demand could absorb 20% of the community production. In the scenarios (C7) and (C8), we compare the impact of market in a context of liberalization. In (C7), we suppose the liberalization of barley and meat markets with random fluctuation of prices with more or less 15%. In (C8), we induce the alternative to sell 20% of the production on the market. Table 14 and 15 show the impacts of the organization of pads' market on the ewe stock (live-stocking) and the cash flow (welfare of farmers).

The four scenarios seem interesting for the farms types without irrigation, except the scenario of liberalization (C7). All the farm types without irrigation (EA1, EA2, EA3) increase their flock size and register a positive progress of their cash flow. It is different for the farm types with irrigation that become potential buyers in the case of the organization of a community market. This explains a reduction of the Gini coefficient from 0.33 to 0.25 owing to this community market.

In the scenario (C7), the liberalization leads to a great de-stocking for the agro-pastoralists (EA1). The main handicap for them is the price fluctuations of barley because these farmers are net buyers. But, the possibility to sell pads' production could avoid this negative impact in a context of liberalization (C8). Besides, the small and medium farms with irrigation (EI2 and EI3) increase their cactus area.

Therefore, the organization of a market for cactus products will have profitable impacts on the different farm types. It would stimulate live re-stocking and slow down the effects of prices fluctuations in a context of liberalization.

5.2 The role of cactus market in the livestock investment in Algeria

5.2.1 Trend of Cactus plantation in the community

In 1995, 19% of the sample (among 60 households) planted cactus. Between 1995 and 2003, the probability to plant cactus increased substantially (50% of the plantations dates during this period) (see figure 5 and 6). Most of the farmers harvested in 1998 (12%) and 2001 (11%). Besides, 56.4% of farmers sold the fruit production in situ, and 34.5% by weight. At the community level, 54.4% sold the pads' production. Marketing agreement took place at the beginning of July (for 68% of the farmers), the collect realized by children (for 38%) and the sales took place in august. 42.1% of the farmers declare to sell to regular buyers and 31.6% sell to the highest bidder.

Since the last drought (1998-2002), the farmers have allocated in average 2.81 ha (with a standard deviation 1.55) to cactus, compared to 1.86 ha (Standard deviation 1.12) the previous years. Also, 47.4% of farmers are willing to increase cactus area, while others, 45.6% are willing to maintain the actual plantations.

Positive relationships between cactus area and cereal area are observed (Table 16). This underlines the importance of this crop for all the farmers and, not only, the small ones.

However, nothing proves any links between cactus area and animal stock (Table 17). The coefficients are positive, but, the probability to accept the nil hypothesis is high.

These empirical data show that the importance of the technology is mainly due to the market. Our objective is, thus, to see if a variation of the price of cactus would have an impact on the cereal area, the animal re-stocking and the inequity at the community level.

5.2.2. Results of simulation

The previous empirical analysis seems to establish that the cactus development will not have impacts on the cereal area, one of the priorities of the Algerian government. In the simulation, we observe that an increase of the price of cactus increased the durum wheat production, but also, the bread wheat (see figure 7). This can be explained by two factors: the cultivated area is generally greater to the own areas due to the practice of sharecropping in the area supposing a good year. During a good year, the fallow is reduced. This adjustment is possible due to the community system of sharecropping. The solution shows that the community equilibrium is achieved with a null vector of Langrage (that is associated to the community land). As long as the land availability is not a constraint, there are complementarities between the Opuntia and the cereal. In fact, the Opuntia could exacerbate the land problems by marking the land owner that is often in a jointly-owned property (this is the case for 33% of the sample). Resistant to climatic stresses, Opuntia constitutes an interesting option for diversification. Taking into account our hypothesis, i.e., maximization of the community objective

function) we conclude that Opuntia is profitable in a technical and economical point of view, and this development is not contradictory with cereal production' objective.

Figure 7 shows that the responses of the farmers are homothetic as if we postulate non linear functions of costs with specific parameters for each individual in the community. At short term, we cannot say that Opuntia development will change the endowments of the smallest ones.

Concerning the community inequity, the homothetic transformation suggests that Opuntia development would not change the intra community inequity. Since the costs are fixed and constant for each farm in the model, the graphics of receipts or profits have the same shape. Thus, the inequity appears to be persistent. This result is explained by the fact that initially, the probabilities to have a Cactus area are almost always positive.

Although the empirical data show no correlation between the flock size and the Opuntia area, the model shows that an increase of Opuntia price could have a positive impact on the small farms in term of re-stocking. As shown in figure 8 the largest farmers do not change their flock size, although, for the smallest ones there are increases. In the model, we suppose that the cactus pads constitute a feed source for animals and, consequently, an increase of prices that allows increasing the production and reduce the relative cost of animal production. So, the feed cost is decreasing for the smallest farms. According to our estimations, during good years, the largest farms allocate the majority of the pads' production to the market and not to animal consumption. In term of inequity, this result could change the community inequity with a reduction.

It appears that an aggregated model, such as, the community model that does not take into account the behaviour of each individual is unable to identify the full heterogeneity of the responses of the farmers. The estimations of the correlations on the results of the simulations demonstrate that the correlation between the simulated ewe number and the planted area in cactus is positive (with a coefficient of 0.06), but, the coefficients are nil to the significant threshold (the p-value of the Pearson test is 0.66). An aggregated model might show the absence of reaction of all the farmers.

In conclusion, neither the statistical analysis nor the model shows that cactus development will affect cereal production. But, it could facilitate sheep re-stocking in the small farms. Besides, nothing indicates changes in the community inequity.

6. Analysis of institutional constraints in the adoption process

Institutional constraints are numerous. In the following, the focus is on the three main factors that, supposedly block technology adoption in the arid and semi arid areas: multi-activity, collective management of rangeland and credit or insurance system.

6.1 Multi-activity, a traditional structural support to agricultural investment in Tunisia

Off-farm activities play an important role in the Tunisian agricultural dynamic, although, this role changes according to the social and economic environment. As early as 1961/62, a survey (FAO, 1962) revealed a rate of multi-activity around 49%. This high rate reflects the political and economic context in the sixties and seventies that was very unfavourable to the rural sector (development of cooperative, loss of the ownership, etc...). In 1994/95, a large survey conducted nearly 471 000 farms confirmed the stability of the rate of multi-activity in the rural areas; the rate was estimated at 43.2%, the maximum rate of 50% was recorded in the small farms (with less than 5 ha) that represented 53% of the population, and the minimum rate of 18.5% for the large farms (with more than 50 ha) that represented 3% of the population. The agricultural survey conducted in 1980 underlined regional disparities: the rate of multi-activity was 46.6% in the central and south part of Tunisia against 36.2% in the North part (Agricultural Survey 1980, cited by Elloumi, 1993). According to Elloumi (1993), these rates were related to the rate of occupation in agriculture[5] and the degree of industrialization (more developed in Center East and South).

Elloumi (1993, 1994) distinguishes 3 types of multi-activity:

[5] The rate of occupation would be around 100 hours per year and per farm in the Central and South part of Tunisia, against 190 hours in the North.

- Multi-activity for survival: the off-farm incomes allow ensuring the simple reproducibility of the farm;
- Multi-activity for supporting agricultural activities and some opportunity for investment;
- Multi-activity for diversification or funding that allows investing in or out of the agricultural sector.

Nowadays, Tunisian agriculture employs only 20% of the total active population and 50% of the rural active population. The central region (Sidi Bouzid, Kasserine, Kairouan), however, registers a low rate of industrialization. The rural employment represents more than 46% of the total employment, with a rural population around 77% in the Sidi Bourid Governorate. In this Governorate, the economic activity, mainly for the young population, is concentrated in large towns, such as, Sfax, Sousse, Gabès and Tunis.

In the Zoghmar community, 71% of surveyed households (in a sample of 316 households) declared having an off-farm source of income with an average annual income of 1000 DT per household in 2002, presented as a bad year. Two thirds of the family labor is employed out of the farm with different rates. The part of the off-farm income is 44% for the small farms (EA3), and only 24% for the large agro-pastoralists (EA1). Therefore, it appears that multi-activity does not play the same role according to the farm type.

For simulation purposes, we propose to test different scenarios:

(i) The role of multi-activity in the regulation of climatic variability.

- Scenario W1: Succession of three good climatic years (2003-2006)
- Scenario W2: Succession of three dry climatic years (2003-2006)
- Scenario W3: Succession of three dry climatic years (2003-2006) with restriction of off-farm opportunities

(ii) Influence of wage conditions on the reproducibility of the farm and the level of intensification. Knowing that the basis monthly wage is around 200 DT for a daily worker, three scenarios are tested:

- Scenario WA1: Increase of the average monthly wage to 300 DT
- Scenario WA2: Increase of the average monthly wage to 300 DT with a reduction of time
- Scenario WA3: Increase of the average monthly wage to 400 DT

(iii) Impact of the restriction of off-farm opportunities (due to reduction of the emigration fluxes and the stagnation in the country). Two scenarios are tested:

- Scenario WL1: reduction of the labor opportunities to 75% of the active family labor
- Scenario WL2: reduction of the labor opportunities to 50% of the active family labor

6.1.1 Multi- activity as a shock absorber of climatic variability

The results in Table 18 confirm the important role of the multi-activity as a way to by-pass bad climatic years. A reduction of the off-farm opportunities by 50% leads to an important live de-stocking (more than 8% at the community level) with some differences between farm types. The sensitivity to the reduction of the off-farm opportunities is more important for the farms with irrigation. The rate of de-stocking for EI1 and EI2 increases by 25-30% with a reduction of the cash flow by 20%. For these farms, off-farm incomes constitute a pillar for funding irrigated and livestock activities, such as, fattening that develops substantially in the farms types with access to irrigation. The number of fattened animals went from 37 to 13 for EI1 and from 12 to 1 for EI2.

The impact is, however, less important in the agro-pastoral farms for which the family members are mainly occupied on the farm. This shows that a certain level of live stocking enhances the value of the family workers. This could favour the development of farm models with a certain size in term of reproductive females through public programs of investment support.

For the different scenarios, few technical changes are observed in the production systems. Only during the succession of good years, the farms (EI2) do not plant cactus, although, they do during a

succession of bad years. This shows that the technology is well adapted for drought conditions and confirms that farmers do not use long term management.

6.1.2 Change in wage conditions

The increase of off-farm income due to wage increases favors the livestock activity in the arid and semi arid areas (Table 19). However, some differences among farmers are observed.

Firstly, for an average wage of 300 DT/month, reduction of off-farm activity favored the live stocking in the farms that benefit from irrigated plots, although, a slight reduction for EA3 and EA1 and stagnation for EA2 were registered. Besides, an increase of unemployment in the small farms (24% for EA3 and 57% for EA2) and a reduction for EI3 and EI1 (6% and 9%, respectively) were also observed.

These results reveal the role of the multi-activity for each type of farms. For the agro-pastoralists (EA1), the impact of wage change is low because these farms have the highest rate of occupation at the family level. For the small and medium mixed farms without irrigation (EA2 and EA3), the reduction of external employment slow down the live stocking and this implies an increase of unemployment. In these farms, the multi-activity is important to ensure the reproducibility of the farm, even the enlarged reproducibility when the off-farm income increases. The reduction of multi-activity threatens their survival. For EI1, the multi-activity plays a role in the investment. The additional increase of the wages allows investing in live capital, but also,: the percent of saving increased from 10% to 19%. For EI3, the presence of irrigation allows investment as soon as the off-farm incomes increase. The savings also increased from 3% to 8%, for an average wage of 300 and 400 DT/month, respectively, compared with the basis monthly wage of 200 DT. The farms EI2 react differently due to the labor constraint. The off-farm incomes are more profitable than the livestock incomes. These farms will invest in animal activity only if there is a reduction of external employment.

6.1.3 Change of labor opportunities in the agricultural activity

Table 20 shows how a reduction of off-farm opportunities (in the industrial or tourism sectors) may affect the rural incomes and agricultural supply. At the community level, with reduction of employment by 50%, the rate of de-stocking is 5.8% and this rate is 17% with a reduction of employment by 75%. On average, the de-stocking ranges between 45% and 18%, except, for EA1 and EI3. For the agro-pastoralists (EA1), the low level of multi-activity explains that agricultural activity is self-funded. These farms are less dependent on the external economic conditions. For EI3, livestock activity is extremely dependant on the off-farm income; this explains the important rate of de-stocking (comparable to the reduction of external employment).

The model confirms for the different scenarios, the multi- varied role ensured by multi-activity at the farm level. This role varies with the structure of the farm and the degree of stocking. But, we note the small technical changes for all the scenarios, except, for the fattening activity in the farms with access to irrigation.

Therefore, changing salary regulations may not have the expected impacts on technology investment, such as, cactus. The farmers seem to prefer productive changes with the substitution of traditional husbandry by fattening, but, without any technical changes. Their effort is focused on the short term gains rather than the long term.

6.2 Organization and rules on the common range lands and technology adoption- case of Ait Ammar (Morocco)

Another institutional feature that might influence technology adoption is the property rights structure. Not only do we expect the decision process on the choice of technology to be trickier in the case of common property rights than private ones, but the benefits of the technology might differ according to the farm types composing the community. In addition, because common resources are characterized by negative externality in their use, technologies aimed at rehabilitating the land (shrubs, fertilization) might not succeed, the extra biomass generated being overgrazed if no management plans are settled.

Herein, attempts are made to understand these phenomena in the case of common rangelands of Ait Ammar community, where a real blockage in the decisions with regards to the improvement of

common resource is observed. Based on survey data of 117 households, our analysis consisted of three main parts: 1) a descriptive analysis of the community and its common rangelands was first undertaken, 2) assessment of rangeland use according to the 7 farm types previously identified, 3) linear programming model for simulation of several technical and management options that would improve the rangelands and observe the impact of each scenario on the extraction level of the different farms.

6.2.1 Ait Ammar rangelands

The rangeland named 'El Ghaba' is the main resource shared collectively by Ait Ammar population. The rangeland is mainly used by the herders of Osimba fraction. This fraction is relatively poorer than Osibra, the households own less land and they rely more heavily on common rangelands for their livelihoods.

The rangeland is located in the northern part of the community. They are the property of the forest domain. It used to be part of a wider area – shared by several other neighboring communes (Ouled Boughadi, Ouled Fennane, Lagfaf) – that were delimited in the beginning of the 1980's. In fact, today, the rangeland is composed of two parts: 'El Hamed' and 'Kron El Otmani'. 'El Hamed' is the forest domain of a neighbouring community with whom Ait Ammar has an agreement to access the land. Ait Ammar herders cannot stay overnight in the rangelands and they have to camp in another site called Tmoutira. A group of 20 households established permanent residency in it, those are most often the sons of flock owners. The Tmoutira is composed of three quarters (North, West and East) that are defined according to grazing itineraries of their inhabitants.

'Kron el Otmani' is a smaller rangeland (150 ha) falling under the forestry regime. It is used principally by herders that own a melk (small plot) at the border. While certain herders live on their melk permanently, others rent or buy a simple spot (without a house) to access the grazing land. The users of 'Otmani' rangeland are estimated to be 60 users.

According to the information collected through the census, 89 herders accessed both rangelands in 2003, which represents 20% of the 429 farmers with livestock. Key informants estimated that 3500 heads grazed the rangeland in Spring 2003 (the most favorable period of the year). This is more than the carrying capacity of 2500 heads. However, data from the census support the thesis of optimal use, since only 2430 animals were reported to use the rangelands.

Whereas range improvement is being undertaken in the neighboring communities, Ait Ammar did not engage in any shrubs plantation (*Atriplex*) or range resting. Among the surveyed households, 90% are opposed to doing so. the main reason being the current overloading.

6.2.2 Farm types and rangeland use

Reconstitution of farm types and their behavior on the rangelands (through the extraction level) in the model are summarized in Table 21 for a reference scenario (average year, no technology). As shown, in this community the main users of the rangelands are the small livestock producers (F4) owing to their relatively big flock size and high extraction level; the medium crop/livestock farms (F5) who own less sheep and graze less on the rangeland, but they are more numerous; than the herders who are permanently settled in the rangeland (F7). The other farms are either more intensive or better endowed in land on which sheep can graze residues (F1), or have a limited number of animals. However, due to their important weight in the community (F6, F3), they can influence the overall results and bargaining between herders.

6.2.3 Technological and management options

In order to understand the blockage observed in the improvement of Ait Ammar rangelands, we tested different technical and management options and evaluated there relative impact on the resource and the exploitation level of the different farm types. Some of the options were proposed in the community development plan (rotation, fertilization), others were official rules that currently were not enforced (grazing taxes), and these were designed by us.

Our model is composed of a relatively simple biological component that does not permit fine resource modelling. Therefore, we evaluated the impact of the option on the resource in terms of the overall

biomass leftovers at the end of the year. Compared to the reference scenario, more biomass left by any option means that the rangelands are healthier and that the technology is efficient.

The different options tested (Table 22) were more or less effective in terms of the overall biomass 'leftovers' and on distribution effect between farm types that are better-off, i.e., extract more biomass, and worst-off, i.e., extract less biomass. Among the technology options, rotation was preferable than a simple increase of biomass by soil fertilization without any management plan because the increase of biomass attracts more flocks on the rangelands and results in a worst outcome than the reference scenario. If the restriction of access to certain animal species or the grazing taxes have positive and similar impacts, the first one favours the structural herders (F4 and F7), whereas the second is disfavouring them. The quota shows also interesting results, switching the pressure from the structural herders to the more opportunistic crop oriented farms results in no improvement. Finally, as expected, opening labor opportunities to community members resulted in more investment in livestock for most of the farms leading to the worst scenario in terms of total biomass left on the rangelands.

If these results are not representing the reality, they still can help us understand the current blockage observed in the community. This is mainly due to two elements:

- The main users of the rangelands, ,the ones who are less land endowed and the poorest households in the community, most of the options are socially non conceivable (grazing taxes, quotas).
- Even if rotation could be a good option, the current high pressure and degradation level of the rangelands make it difficult to implement, according to the herders.

Still, the model can help in supporting collective decision making including modeling other options drawn by the beneficiaries themselves.

6.3 Credit constraint and insurance system in arid and semi arid area

6.3.1 The constraints of credit access

The access to credits is often mentioned as the main obstacle to the adoption of technology, but also, to the reproducibility of the farm.

In Algeria, only one third of the farms benefits from credits and 70% of the credits are informal credits within the enlarged family or the tribe. The bank credits concern only 6.6% of the households in the community. These are mainly long term credits (5 years) for large farms, and the credit amount is in average 350000 DA.

The credits are allocated to the re-stocking in live animals (31%) and to the funding of the agricultural campaign (26%). The rest concerns either social expenditure or equipment purchase. The most important credits (around 888 000 DA) are allocated to large mixed farms. The average credit of medium farms is around 200 000 DA. The group of herders in the phase of re-stocking obtains credit around 40000 DA on average; the same as for the oldest farms.

At the opposite, the small farms do not receive any credits in the informal nor the formal systems. If the informal credit is working well it is reserved for large and medium farms. The average credit in the enlarged family is around 75000 DA.

Also 28% of the farms lend money to friends or family members. The average loan is around 90500 DA. But, some large farmers lend even more than 2,000,000 DA.

In Morocco, 36% of the surveyed households obtained either a formal or informal credit. Around 37.5% of the credits allowed reimbursing the debts of the previous ones. Besides, 34.4% permitted developing fattening (purchasing of lambs and feeds) and 28% served to fund the agricultural campaign (mainly purchase of seeds). The credits for reimbursing previous debts were 35 800 Dh on average, against 25 300 Dh for the livestock activity and 2800 Dh for the agricultural campaign. It is worth noting credits need for the livestock activity, especially after a drought, for live re-stocking.

Among the 32 households who did not receive any credit, 34.3% of them mentioned the lack of livestock as mortgage. The flock being more a guarantee to access to credit than savings. The second factor that limits the access to credit is that the majority of land is in dispute within the enlarged family; that represents 21.8% of the farmers for whom the credits were denied. Finally, there are

other reasons of formalities and age. The oldest farmers have many difficulties to obtain credits access.

In Tunisia, the main constraints to access to bank credits were the jointly owned property (that represents 33% of the surveyed households), the age of the farmer (18%) and the administrative procedure (15.3%). Within the community, 74% of the farmers declared demanding credits near family members or neighbors for funding the agricultural campaign; 61.5% declared that the limitation to credit access constitute a constraint. and among the 20% who declared that credit is not a constraint, the majority of them have an off-farm activity.

When the question, "what would you do with credits?", was asked, 64.1% wish to practice animal trade and only 20% to invest in agriculture. This reveals the importance of the livestock business in the region. In fact, 56.4% of the farmers attempted to make a feed stock during summer (the period of barley harvesting), but the old, young and small farmers were having difficulties.

During the 2003-2004 growing season, all the farmers in the community received credits, but, 84% were informal credits and 12.8% were credits realized in development projects. Around 51.3% of the credits were reserved for purchasing feed and 20% for the family. The rest was allocated to equipment or various investments. The average credit was around 1500 DT/year.

The results from the survey underline the problem of credit access in the agro-pastoral regions, notably for feed purchase. The farms surveyed face two main problems:

- The absence of land guarantee when the majority of the capital is live capital. More than one third of the credits refusal are due to the problems of inheritance and jointly own property.
- The majority of credit is for agricultural campaign and not for livestock activity. But still, 31% of the credits in Algeria, 34% in Morocco and 51.3% in Tunisia were allocated to livestock activity.

Although, no one mentioned any rate of interest for the informal credits, one can imagine that this credit may create some dependencies between families. All these imply that it is time to think about new forms of guarantee based on livestock activity or insurance system. In this regard, the Moroccan case study is interesting because the governmental authorities with the World Bank are actually testing different forms of insurance systems.

6.3.2 The establishment of an insurance system in arid and semi arid area

To rehabilitate the cereal crops, the MADRPM in collaboration with the Ministry of the Economy and the Finance, the CNCA and the MAMDA put in in an application for a program test of guarantee of the cereal production against drought-risks. This insurance system is in line with the general objective of the government in the matter of agricultural development objectives, mainly, to ensure food security and income safety. Therefore, the main objectives of this insurance system are:

- Motivate the farmers for the investment
- Guarantee the recovery of debt for the CNCA
- Lightening and best allocation of the public support during drought

The first insurance system aimed to guarantee the cereal production (durum wheat, bread wheat and barley). This program was tested in different regions during the agricultural campaign 1999-2000. The levels of production were fixed on the basis of expert surveys that took into account the potentialities of each region. To resort to this insurance, the farmers were obliged to follow some specifications on the technical management and according to the level of indemnities. The compensation (or indemnity) of the members for the damage was established on the basis of unit price per quintal for barley (130 DH), bread wheat (200 DH) and durum wheat (220 DH) and on the basis of the difference between the guarantee amount and the observed value of grain harvest, as:

Indemnity (dh/ha) = guarantee value – [unit price (dh) x observed yield (Qx/ha)]

Faced with the risk of failure of this system (administrative charges, moral risk and anti-selection), a new system was launched by the World Bank based on the rainfall index. A coefficient of variation was generated to calculate the compensation based on the rainfall index. It constituted the main criterion for the formulation of the insurance contracts when the risk distribution is normal. Therefore, the contracts were proportional and the compensation represented a given percent for the different

levels of rainfall below a certain level. The compensation depended on the difference between the observed level of precipitations and the pre-determined thresholds. So, the compensation is calculated:

*Indemnity = % of the payment * Value or total loss in Dh*

The amount of the insurance premium is:

*Insurance premium= rate of subscription * value or total loss in Dh.*

Another point that merits examination is the existence of contracts based on the combination of both the rainfall index and the income per ha. This study shows that the combination of the two types of contracts allow greater results on the minimization of the relative risk. "If the percentage of the compensation on the contact based on the rainfall index is lower than the compensation based on the income per ha, the new amount is then the compensation based on the income per ha". Then, the compensation based on the income per ha is calculated as:

Indemnity = (threshold of income - effective income) / threshold of income

In the following, we propose to simulate the impact of an insurance system in the Moroccan community. A new endogenous variable was determined for each crop, type of contract (level) and farm and some equations that specify the terms of contracts. A set of parameters specifies the coefficients of the insurance system.

The insurance system is adopted by all types of farm in the optimal solution and all the cereal cropped areas are ensured. The types of contracts are level 1 for wheat and 1 and 2 for barley. In the simulation, the insurance system allows pushing back the frontiers of the efficiency of risk by either the improvement of incomes or the reduction of risk; the two objectives can be achieved in the same time (Table 23). This is the case of the types of farm F1 and F6: they improve their average income by 3% and 5% and reduce the incurred risk, i.e., the sum of the absolute deviations (reduction of 24% and 48%, respectively). These two types of farm represent stable groups; they are either retired persons who benefit from monthly indemnity of retirement or large farms with a certain level of security. The types of farm F2, F5, F4, F3 opt for a strategy of improvement of their income (by 7%, 10%, 4%, and 8%, respectively), although the type F7 maintains its income but reduces the risk by 36%. The type F7 gathers the farms that live in the common rangeland and use more degraded land. Their objective is to secure cereal supply for the family's self consumption. The other types suffered during the last droughts (1998-2002) and, therefore, their objective is to increase their income for re-stocking.

Generally, the insurance systems change more with important intensification and less diversification; the durum wheat could be given up, the area of bread wheat could be reduced, although, the barley registers an increase of its area by 9%. The farmers who reduce the wheat area belong to the types F5 and F6, i.e., retired persons or farmers in the phase of live re-stocking. The types F4 and F7 may not follow this tendency and could increase the area of bread wheat; these types are small farmers without land security. With the insurance system, these farmers attempt to secure the cereal supply for self-consumption.

The clearer tendency is the intensification of the livestock activity. The number of reproductive animals does not change very much, but, the lambs' production increases by 6% in summer and 10% for Aïd El Kebir. The goat activity may decrease; the reproductive flock is reduced by 3%.

The types of farm that intensify the lamb production are the type F2 for the lambs for Aïd El Kebir (increase of 46%) and the type F5 for the lambs of summer (increase of 13%). The type F2 have generally an off farm activity and consider their flock as an investment. The type F5 is the most specialized in the livestock activity that represents 75% of the family income.

The Moroccan government intervenes through the subsidies of insurance premium and the fund for the natural calamities (F.C.N.) in order to cover the deficit between the subscriptions and the compensations. The contribution of the fund of natural calamities is limited to 137 millions Dh. The extension of the insurance system to arid and semi arid areas may then affect the viability of the insurance institution. The simulation of the insurance system at the community level allows establishing a first balance sheet:

Annual contribution of the farmers	=	440879.01 Dh
Annual subsidies of the government	=	440879.01 Dh
Reimbursement (annual average)	=	1124268.60 Dh
Contribution of the F.C.N. (annual average)	=	242510.59 Dh

The total subsidies of the system (including the subsidies of the insurance premium and the F.C.N.) would be around 60.8%. The government would be obliged to use the funds of natural calamities in a structural manner for an amount of 242 000dh per year on average for the community.

In this context, the questions are: what would be the contributions of the FCN at the end of the public subsidies? Would this contribution be increased progressively with the reduction of the subsidies? IWill this affect the demand for insurance?. New simulations were run with a reduction of the subsidies on the premium from 50% to 0%.

Table 24 shows that the insurance system is favorable for all the farms at Ait Ammar; the demand does not decrease and the total subsidies could be reduced from 60.8% to 22%.

The insurance system defined as such, would it be viable without state intervention?. Table 25 shows that the demand for insurance may be maintained with a 20% increase of the insurance premium, but, it becomes very elastic. In order to maintain the demand at a level superior to 70% of the cultivated area, a minimum rate of subsidies of 7% is required.

The use of the model in the analysis of the application of an insurance system in arid and semi-arid area shows that an insurance system could contribute to the stability of farm income in an efficient way. It could influence the behaviors of the farmers and induce some changes in the farming systems (with some technical improvements). In this regard, the insurance system opens wide perspectives for the agricultural policies. However, it needs public support.

7. Analysis of constraints of input supply and impact of the liberalization

7.1 The supply in feed

Surveys through free interviews were conducted with traders of feed in Tunisia and in Morocco. The information collected was completed by the collected data of the farmers for the three countries in the matter of feed supply.

In Morocco, the traders interviewed were sales agents of barley grain and concentrated feed (bran, pulp of sugar beet, maize, mixed feed). These sales agents were mainly retailers and they bought the mixed feed in Casablanca and the bran in different provinces (Khourigba, Kenitra). In general, they have their own vehicles. During high sales periods or in the case of vehicle problems, the agents rent vehicles for 0.10 Dh/Kg transported. The main periods of sales are the two months before Aïd El Kebir. During the rest of the year, the sales depend on the climatic conditions. The main points of sales are Ait Ammar, Lagfaf, Ouled Ftata and Lagnadiz in the region. They sell directly to the farmers and the stock passes by 15-20 days. The toughest part is the waiting in the manufacturers or mills, especially, for mixed feed and bran.

The sales agents estimated their margin at around 0.10 to 0.15 Dh/kg. In fact, more important margins reaching 0.5 Dh./Kg sold are observed (Table 26).

The gaps among purchase prices at the farm level vary according to the places of purchase. The purchase prices in the souk of Lagfaf are inferior to the ones in the community of Ait Ammar. Thus, the small farmers who are located far away from the road and without any mean of transportation are the most handicapped.

The sales agents of hay of Lucerne are originated from Oued Zem (a town located 40-50 km from Ait Ammar), and they buy the hay at Fkih Ben Salah (a town located 60-70 km for Ait Ammar). The margins are quite high for these sales agents; they buy the bundle of hay around 20-25 Dh and sell it at 50-55 Dh/ bundle (one bundle weigh approximately 17 kg). The margin increases during dry years.

The household survey conducted in 2003 among 87 farmers showed a high variability of purchase price for different feeds (Table 27). The price of barley grain tripled between a good and a bad year , and the prices of straw were multiplied by 6.

Therefore, the main handicap at the farm level is the high variability of prices according to the climatic years, but also, the leap in prices during bad years.

In the case of Tunisia, however, the main sales agents of concentrates are dealers with franchise of the Cereal Office and the regional council of development in the Governorate. The agreement of the Cereal Office requires having a space (garage or hangar) with a capacity to receive 25-30 tons of barley. The Cereal Office delivers the barley grain directly and the bran to the dealers and fixes the profit at 0.5 DT/quintal. The total profit of the dealers depends on the demand (flock size in the region, climatic year, purchasing power of farmers) and the competition in the region between dealers. In Tunisia, the cereal office has 160 sales points. But, the number of dealers varies according to the climatic year. In the delegation of Jelma (the place of supply for the farmers of the community), the number of dealers was 10 in 2002 (dry year) and 4 in 2004 (Good year). There are also private retailers of feed. Due to the multiplication of dealers of the Cereal Office, there is now high competition and, in Jelma alone, they are 8 of them. They are specialized in hay and straw; they buy the products on the local weekly markets or in the North part of Tunisia, where they have a place of storage during the dry years. The margins are quite low: an average of 0.3-0.5 DT per bundle of hay or straw and 1DT par quintal of barley grain and bran. Their main source of success is their good local knowledge of the demand and to specialize in products of good quality searched by the farmers. Then, they can make a better margin. They have a limited scope of ones' activity; their main consumers are small farmers with whom they practice credit selling. Compared to the dealers, the number of retailers and the quality sold vary according to the prevailing climatic conditions of the year.

Finally, there are itinerant agents who sell hay, straw and bread. They come from various places: cereal farmers from the North, wholesalers from the M'hamdia delegation (20 km from Tunis), regional traders who can buy and sell in the same places. They are present in all the weekly markets of the region. They sell hay and straw in small quantities to the small farmers and important quantities to retailers or large farmers in the region. The prices vary with the demand/supply in the region, the quality of the products and the climatic conditions of the growing season.

Although, the Tunisian herders are protected from price variation on barley grain and bran, the prices of straw and hay are, respectively, multiplied by 5 and 3 between a good and bad year (Table 28).

The barley grain and the bran are mainly bought in May at time of harvest. In 2003, this period fitted well with the end of Aïd El Kebir and the farmers were able to rebuild their cash flow. But, two third of farmers bought the hay and the straw just before Aïd El Kebir (in January) which explains some speculations on the price. The period of purchase varies with Aïd El Kebir and Ramadan, but also, with the biological cycle of the pasture. Moreover, there are price variations according to the types of farmers. Generally, the young farmers buy feeds 4-5% more expensive; this is due to the lack of local knowledge and the absence of social network. The farmers with an off-farm activity in town buy, in general, the straw at higher prices and the bran at lower prices. In fact, these farmers with their activity in the delegation have more facilities with the dealers.

In Algeria, no survey was conducted among sales agents of feed. But, the household survey allowed approaching some trends on the feed price (Table 29).

In the Algerian community, 42% of the farmers declared that the main handicap for re-stocking in live animals is the feed supply. Among them, 20% (60 farmers) are willing to increase the cactus area and 80% to change the feeding system.

7.2 Impact of the liberalization of input markets on farmers' livelihood in Tunisia

The variability of feed prices, more than the feed supply, constitutes the main handicap for the farmers. The average variation ranges from 3 to 5 for the different feeds according to the prevailing climatic conditions of the year. Even though, the different governments in each country of the Maghreb try to limit the speculative behaviours for the barley grain and the bran during the dry years, the herders declare many injustices on the sale price of these products. This speculative trend would be increased with increasing specialization of the regions as we observe in Morocco and Tunisia

between productive areas of fodder and livestock areas. This trend would also intensify with the liberalization and the reduction of the subsidies. But, on the other hand, a low adoption of technologies of feed storage is observed.

In the Tunisian case study, we simulated the impact of changes of barley price. According to Radwan and Reiffers (2003), a regional liberalization in the North and South Mediterranean region would lead to a reduction of the barley grain by 7.5% in average, and may reach 15% maximum. For a 15% reduction and an average price of barley around 23 DT/quintal (price 2003), the price of barley would be 19 DT/quintal. In fact, a reduction of the price of barley would have a much mitigated impact since the farmers are potential sales agents in good years and structural purchase's agents in dry years.

In the scenario of reference (2002), the price of barley was 19 DT/quintal in good and medium years and 17 DT/quintal in dry years (subsidized price). In 2003, the average price was 23 DT/quintal (survey data, 2003). We propose then the following scenarios:

- Scenario A1: an average price of barley around 19 DT/quintal whatever the year; this is a reduction of the price by 15% due to the liberalization.
- Scenario A2: an average price of barley around 22 DT/quintal whatever the year; this is a reduction of the price by 7.5% due to the liberalization.
- Scenarios A3 and A4 are, respectively, the scenarios A1 and A2, but, with a succession of dry years.

We observed few impacts on the ewe stock compared to the reference with a price of 19 DT/quintal. Only the abolition of the subsidies of 2Dt/kg during dry years led to a live de-stocking (scenario A3). Also, the increase of barley price had various impacts according to the types of farmers. The agro-pastoralists suffered the most with this measurement because they are not sales agents. But, the small farmers (EA3) increased the barley area (92% of the cereal area) and increased the reproductive flock. With the increase of barley price, a reduction of the feed expenditure of farmers with irrigation was observed. These reductions ranged from 14% to 35%.

For the liberalization, 2 scenarios are proposed:

- Scenario (L1): a reduction of barley grain price by 15% (19 DT/quintal) with a random variability of more or less 20% concerning barley grain prices and live animal prices.
- Scenario (L2): the random variability of more or less 20% concerns all the feeds (grain, straw, hay).

For the two scenarios, the agro-pastoralists were the most handicapped, although, the small farms increased their reproductive flock (table 32). In fact, the small farms reduced the barley area (from 91 to 60% of the cereal area) and increased the durum wheat area that was marketed to buy barley grain. At the same time., the agro-pastoralists did not reduce the barley grain for fear of being short of barley grain.

Finally the liberalization of barley and red meat sector may have little impacts on the farms with irrigation because of the diversification of the cropping system. In the dry areas, the agro-pastoralists may be the most vulnerable, although, the majority of small farms with not much land profits of the reduction of barley price for live re-stocking.

8. Conclusion

From our hypothesis related to the problems of technology adoption, market organization for cactus products will have the greatest impact on the adoption of cactus technology, the maintenance of livestock activity that is well adapted in the arid and semi-arid areas knowing that the expected yield of cereals are low, as it has been shown in the Tunisian and Algerian communities. This encourages the development of research on the different marketing channel options concerning cactus products (Sanders et al, 2002). These cactus markets would allow diversification of the systems and a reduction of the dependence of marketed feed during dry years. In the context of liberalization, cactus marketing could reduce the negative impacts for the large agro-pastoralists. In Algeria, this marketing opportunity would permit live re-stocking in the small farms.

The interests and viability of institutional arrangements on common rangelands (such as regulation, specific entry rights) show very controversial results, as demonstrated in the Ait Ammar community (Morocco), mainly, when the demographic pressure is too high on the resource,.

Interventions on wage conditions had few impacts on the technical changes. However the actual reduction of off-farm opportunities (mainly non skilled labor) could question one of the main pillars of survival for the small farms in Tunisia.

An interesting option for these areas is the establishment of an insurance system as it has been shown in Morocco. All the farms seem to be ready to subscript but at different levels, and the system will play an important role on risk management in these very uncertain environments.

Finally, the simulations on risk attitude and the planning period of the farmers show that the main handicap for natural resource management options, such as cactus, is the short term management of the farmers. This explains their large adoption of the fattening activities during the past few years, by contrast to plantations that require time and patience before using them. This will justify financial support to allow flexibility of the repayment period. Moreover, as for all technologies, the lack of experience and knowledge on the expected outputs limit the level of adoption.

We can say that the model constitutes an interesting tool to simulate different scenarios and analyze the interactive effects of economical and technical changes (such as liberalization and cactus market implementation), or even technical and institutional changes (such as the entry tax and fertilization on common range land). The model has confirmed some hypothesis, but, it has also shown the various impacts according to the farm types. So, the aggregation may constitute a limit to approach the individual behaviors that compete with other farms. The farm types are limited compared to the greater observed heterogeneity. The Algerian model, which takes into account the set of the farmers in the model is, thus, original (60 households in the model). But, this necessitates the use of others ways of calibration.

The built models do not, however, integrate all the complexity of the interactions of the agents neither at the market level nor the community level. This implies to develop more sociological approaches of the agents, and then, to integrate them in the modeling approaches.

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Figure 1: Distribution of Community Resources in Ait Ammar, Morocco

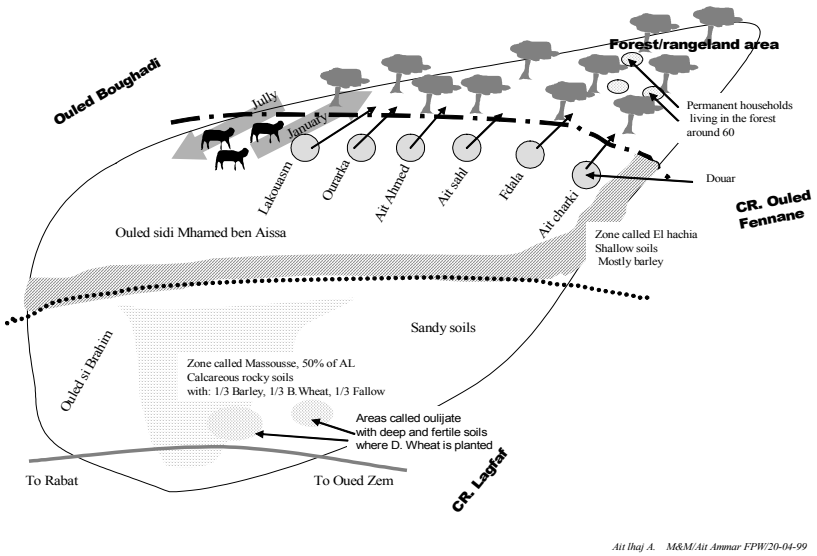


Figure 2: Schedule of the Community Model

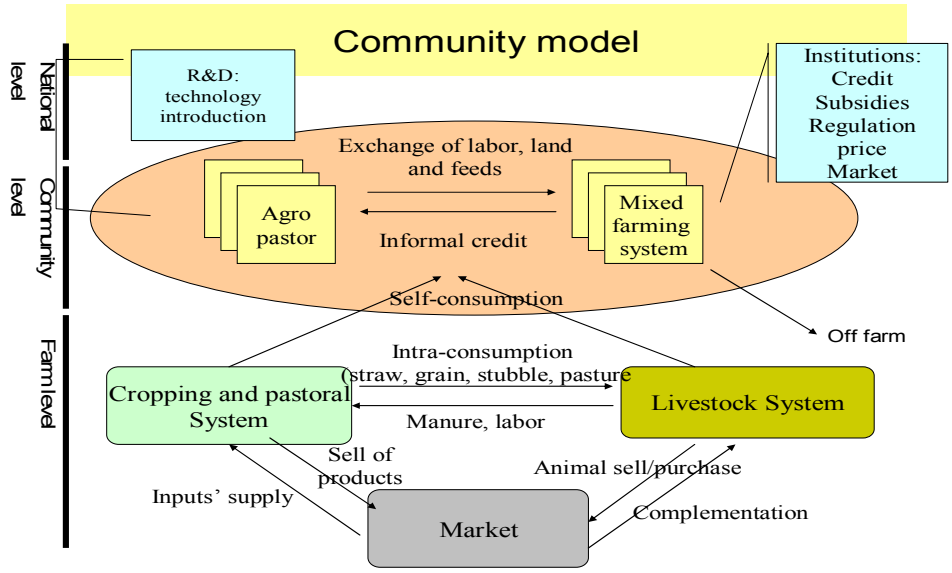


Figure 3: Compared Analysis between Flock Size and Own Land for Each Community

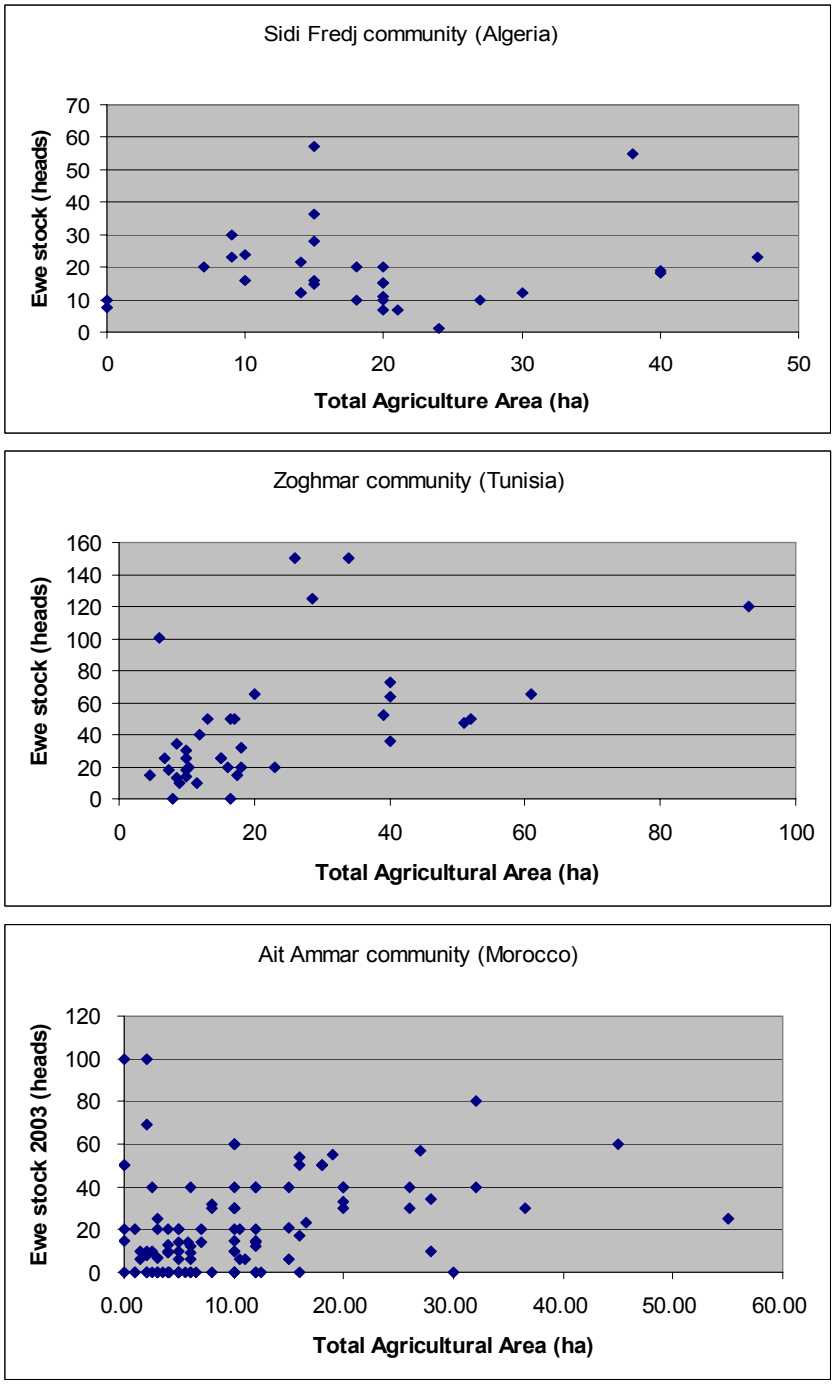


Figure 4: Relationship between Off-Farm Income and Flock Size

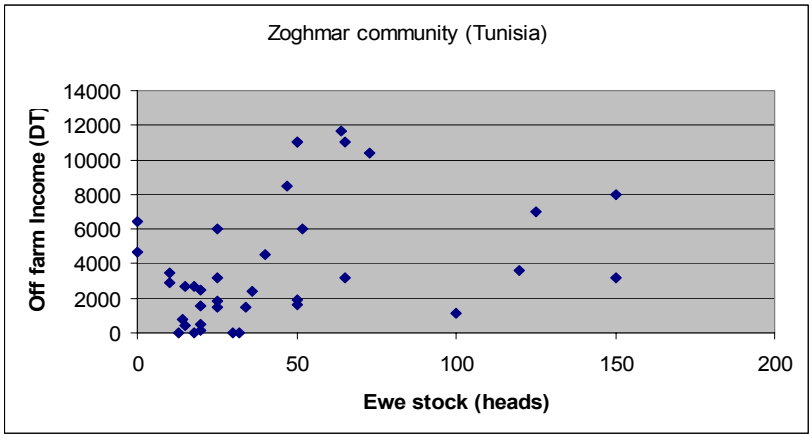


Figure 5: Distribution of the Dates of Cactus Plantation in Sidi Fredj Community (Algeria)

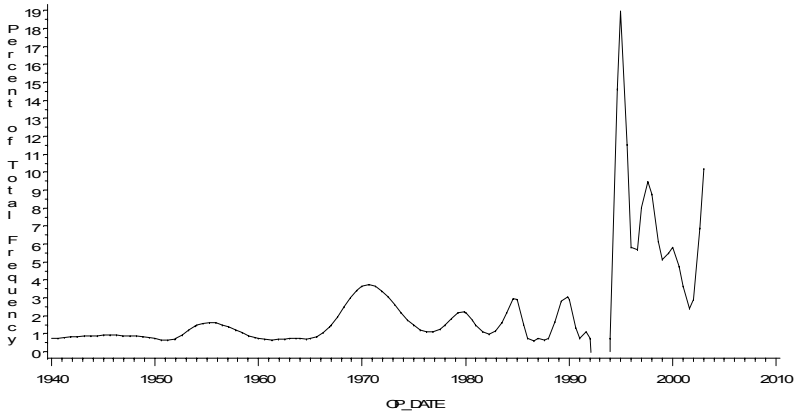


Figure 6: Distribution of the cactus area for 60 households in Sidi Fredj community (Algeria)

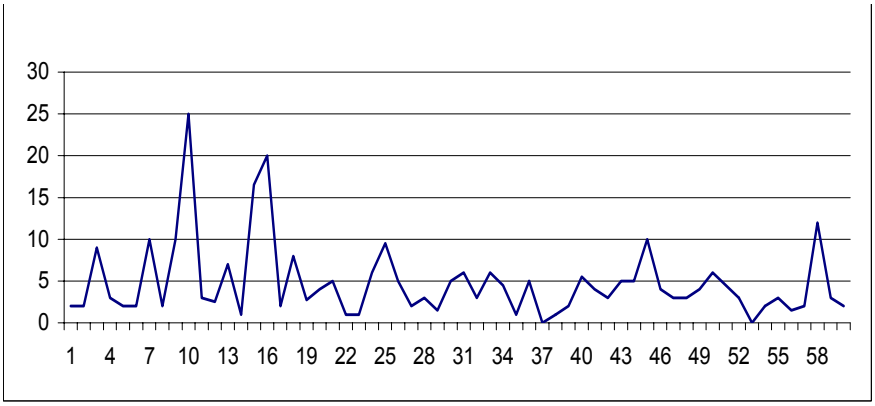


Figure 7: Simulation of the impact of the increase of the unit price of cactus on cereal area (Algerian community)

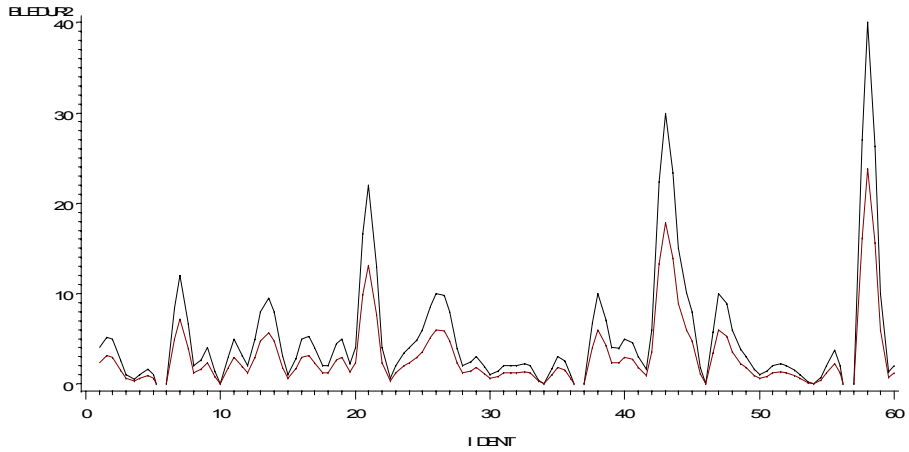


Figure 8: Simulation of the Impact of Opuntia Price on the Ewe Stock (Algerian Community)

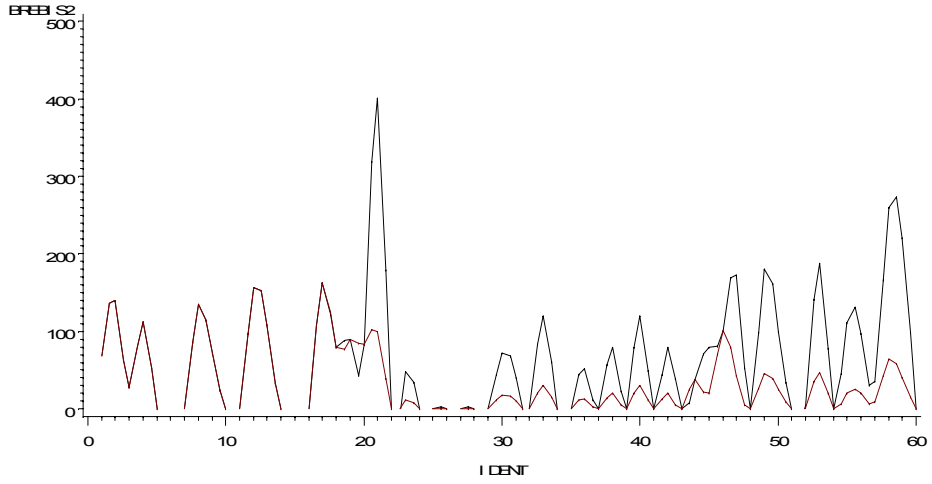


Table 1: Indicator of Rate of Adoption for Different Technologies in the M&M Project (Shideed, 2001)

Technologies	Algeria	Morocco	Tunisia
Cactus	40 %	D	**36%**
Improved rams	6 %	-	**20.5%**
New barley seed	D	45%	**??**
Vetch	-	-	**10.3%**
Feed blocks	D	-	**13%**
Atriplex	-	D	**-**
Fertilization/rotation On rangeland	-	D	-

Notes: Legend: (D) at the stage of demonstration

Table 2: Technologies tested in the FEMISE II project

Package	Technology	Algeria	Morocco	Tunisia
Innovation technology + Market	Cactus			
	Feed Block /vetch			
Innovation technology+ Institutions	Fertilization+ rotation on range land			
Institutional innovation	Insurance system			
	Multi activity			
	Policies			

Table 3: Production, Exchange and Food Balance in SR Meat (in %)

Items	Country	1961	1970	1980	1990	1995	2000	2001
Production (Mt)	Algeria	39,900	50,000	71,433	142,405	178,450	176,350	177,350
	Morocco	65,200	70,800	71,000	121,835	132,000	147,000	147,000
	Tunisia	25,380	20,240	27,430	46,300	54,000	63,900	66,200
Importation (Mt)	Algeria	2,035	0	4,038	6,123	2,065	6,090	663
	Morocco	0	0	0	82	202	109	55
	Tunisia	0	0	715	345	197	0	0
Exportation (Mt)	Algeria	11	18	0	0	0	0	0
	Morocco	16	32	0	0	29	19	2
	Tunisia	0	365	0	0	0	0	0
Consumption	Algeria	41,924	49,982	75,471	148,528	180,515	182,440	178,013
(Mt)	Morocco	65,184	70,768	71,000	121,917	132,173	147,090	147,053
	Tunisia	25,076	19,634	27,820	46,134	53,600	63,198	65,469
Coverage of	Algeria	95.17	100.03	94.65	95.88	98.85	96.66	99.63
needs (in %)	Morocco	100.02	100.04	100	99.93	99.87	99.94	99.96
	Tunisia	101.21	103.08	98.60	100.36	100.74	101.11	101.11

Source: FAOSTAT, 2004

Table 4: Total Consumption of Meat (in kg/person and per year) and Part of the SR Consumption in the Total (in %) (FAOSTAT, 2004)

		1961	1970	1980	1990	2000	2001
Meat consumption	Algeria	12	8.3	11.1	17.9	18.8	18.1
(kg/person/year)	Morocco	13.8	13.1	12.4	18.3	19.3	19.5
	Tunisia	12.2	10.5	15.6	19.4	25.6	25.5
Part of SR meat in the	Algeria	32	43	36	34	32	32
total meat consumption	Morocco	40	35	30	27	25	25
(in %)	Tunisia	48	36	28	29	26	27

Table 5: The Balance Sheet of Sheep Meat in 2003 (in millions of heads)

	Algeria	Morocco	Tunisia
Number of reproductive female sheep	10,4	9,7	4,0
Number of produced lambs (numeric productivity of 85%)	8,8	8,2	3,4
Number of male lambs	4,4	4,1	1,7
Border commercial balance	-1,0	+0,5	+0,5
Availability on the national market	3,4	4,6	2,2
Estimation of need on the basis of one male per 7 inhabitants.	4,4	4,3	1,4
Number consumed in the national market for the sacrifice	3,4	4,3	1,4
Availability of males for the butcheries	0	0,3	0,8
Old female that are self consumed	1,5	1,5	0,6
Young female sold to the butcheries	2,9	2,6	1,1
Total balance sheet in the channel of butchery millions of heads	2,9	2,9	1,9
Thousand ton	43	43	28
kg/habitant/year	1,5	1,5	3
Part of male young for Aïd El Kebir in the total consumption	54%	60%	42%

Table 6: Average Purchasing and Selling Price during Aïd El Kebir and out of the Period in Tunisia (DT/head)

		Aïd El Kebir				Rest of the year			
		Av. purchase price	Race	Average selling price	Margin	Av. purchase price	Race	Average selling price	Margin
Urban Market (Tunis)	Abattoir	164 [33.64]	Barbarine	246 [33.64]	82	98.57 [23.57]	Barbarine Indifferent	159 [17.72]	60
	Ariana	173 [35.45]	Barbarine Indifferent	252.8 [43.2]	80	117.5 [31.39]	Barbarine	171 [40.37]	53
	Cité Ettadhamen	135 [31.62]	Indifferent	243.75 [25.31]	109	97.5 [17.67]	Indifferent	157.5 [3.53]	60
Rural market	Jelma	176.25 [37.29]	Barbarine	213.12 [31.38]	37	115.7 [34.81]	Barbarine	143.6 [33.13]	28
	Sidi Bouzid	189.4 [62.57]	Indifferent	212.6 [65.67]	23	136.3 [28.60]	Indifferent	162.4 [29.45]	26
	Sbeitla	152.71 [49.78]	Indifferent	219.14 [38.77]	66	141.6 [38.55]	Indifferent	185.3 [33.38]	44

Table 7: Range of Purchasing and Selling Prices for Live Animals (Survey of 23 Farmers at Sidi Fredj, Algeria, 2004)

Transaction	Category of animals	Average price	Maximum price	Minimum price
Purchase	Ewe	16.441-19.029	20.000-5.000	9.000-12.000
	Lamb of 6 months	9.882-11.187	15.000	6.000-8.000
Sale	Lambs of more than 12 months	16.631-18.579	22.000-24.000	9.000-10.000
	Lambs of 6 months	9.210-11.236	13.000-15.000	6.000-8.000

Table 8: Range of Purchase and Sale Prices With the Official Rate of Exchange (Survey of 23 Algerian Farmers of Sidi Frejd; 40 Tunisian Farmers of Zoghmar ; 1DT=57.6 DA).

		Average price in DA		Average price in DT	
		Algeria	Tunisia	Algeria	Tunisia
Purchasing	Ewe	16.441-19.029	11.530-17.295	285-330	200-300
	Lamb of 6 months	9.882-11.187	5.400-7.500	171-194	95-120
Selling	Lamb of 12 months	16.631-18.579	12.683-19.024	288-322	220-330
	Lamb of 6 months	9.210-11.236		159-194	

Table 9: Range of Purchase and Sale Prices With the Official Rate of Exchange (Survey of 23 Algerian Farmers Of Sidi Frejd; 40 Tunisian Farmers of Zoghmar ; 1DT =74 DA)

		Average price in DA		Average price in DT	
		Algeria	Tunisia	Algeria	Tunisia
Purchasing	Ewe	16.441-19.029	14.800-**22.200**	222-257	200-300
	Lamb of 6 months	9.882-11.187	7030-8.880	133-151	95-120
Selling	Lamb of 12 months	16.631-18.579	16.280-**24.420**	224-251	220-330
	Lamb of 6 months	9.210-11.236		124-151	

Table 10: Comparison of Average Price of Animals, Unit Feed Cost Per Head and The Average Minimum Monthly Wage for Each Country (In US$)

	Morocco	Algeria	Tunisia
Ewe price	110	200	181
Lamb price	130	161	159
Cost of feed per head	49	69	58
Gross margin per head*	81	92	101
Average minimum wage	170	130	160

* This gross margin doesn't integrate the maintenance of the ewe.

Table 11: Variation of ewe stock for the different scenarios (in % of deviation from the situation of reference) (Tunisia)

	C1	C2	C3
	Planning Horizon	Reduction of risk aversion	Increase of risk aversion
EA1	-12.95	17.18	-20.39
EA2	-16.17	2.79	-4.86
EA3	3.82	0.00	0.00
EI1	52.81	0.00	0.00
EI2	11.97	0.00	0.00
EI3	0.00	0.00	0.00

Table 12: Variation of Cash Flow for the Different Scenarios (In % of Deviation from the Situation of Reference) (Tunisia)

	C1	C2	C3
	Planning Horizon	Reduction of risk aversion	Increase of risk aversion
EA1	-9.25	-5.57	30.22
EA2	-6.92	-5.53	-1.32
EA3	-4.45	0.00	0.00
EI1	-27.17	-1.82	1.10
EI2	-13.33	0.00	0.00
EI3	-49.44	0.00	0.00
Community	**-8.87**	**-1.39**	**0.02**

Table 13: Adoption Level for the Different Scenarios in Tunisia (Area Planted in Cactus in Alley Cropping in ha)

	S1	S2	S3	S4	S5	Survey	
Farm type	Adoption level without OEP incentive	Adoption level without OEP subsidies+ 30% yield	Adoption level with limited OEP support	Adoption level with limited OEP support And yield increase	Adoption level with no restricted subsidies	Area of cactus in alley cropping	Area with spine cactus
EA1	0	5.78	5	16.53	16.5	5	8
EA2	0	2.93	1	2.93	2.9	1	2
EA3	0.29	3.34	3.34	3.34	11.4	2	2
EI1	10.21	29.17	30	45.6	50	30	
EI2	2.67	3.85	2.67	3.85	5.5	0	0.5
EI3	0	10.75	5	11.23	14.25	5	1

Table 14: Variation of Ewe Stock for the Different Scenarios of Markets (in % of Deviation from the Reference with No Market) (Tunisia)

	C5	C6	C7	C8
	Community market	Regional market that absorbs 20% of the supply	Liberalization on meat and barley sectors	Liberalization + Regional market that absorbs 20% of the supply
EA1	23.07	22.76	-20.08	23.39
EA2	44.33	43.20	6.22	54.94
EA3	68.48	68.96	17.24	116.45
EI1	-4.87	0.00	0.00	0.00
EI2	-1.57	2.17	-2.05	3.27
EI3	0.00	0.00	-2.87	-9.75

Table 15: Variation of Cash Flow for the Different Scenarios of Markets (in % of Deviation from the Reference with No Market) (Tunisia)

	C5	C6	C7	C8
	Community market	Regional market that absorbs 20% of the supply	Liberalization on meat and barley sectors	Liberalization + Regional market that absorbs 20% of the supply
EA1	9.24	22.35	45.11	34.39
EA2	11.23	11.83	0.80	13.16
EA3	21.66	21.58	2.61	20.47
EI1	-14.47	9.15	-2.46	0.57
EI2	-28.49	-0.38	-3.28	-4.37
EI3	3.58	11.36	1.62	10.36
Community	**15.30**	**18.32**	**5.14**	**18.36**

Table 16: Matrix of Correlation between the Cactus Area and the Cereal Area in Sidi Fredj Community (Algeria)

Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0 / N = 60				
	OPUNTIA	**BLEDUR**	**BLETEND**	**ORGE**
OPUNTIA	1.00000	0.34047	0.32867	0.27293
	(0.0)	(0.0078)	(0.0103)	(0.0349)
BLEDUR	0.34047	1.00000	0.60971	0.63879
	(0.0078)	(0.0)	(0.0001)	(0.0001)
BLETEND	0.32864	0.60971	1.00000	0.64354
	(0.0103)	(0.0001)	(0.0)	(0.0001)
ORGE	0.27293	0.63879	0.64354	1.00000
	(0.0349)	(0.0001)	(0.0001)	(0.0)

Notes: Between parenthesis the p-values

Table 17: Matrix of Correlation between Cactus Area and Animal Stock in the Sidi Fredj Community (Algeria)

	Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0 / N = 69					
	BREBIS	**BELIER**	**CHEVRE**	**OPUNTIA**	**BOUC**	**AGNEAUX**
BREBIS	1.00000	0.38413	0.53078	0.15106	0.28773	0.05420
	0.0	0.0011	0.0001	0.2153	0.0165	0.6583
BELIER	0.38413	1.00000	0.21556	0.01572	0.54982	0.00510
	0.0011	0.0	0.0753	0.8980	0.0001	0.9668
CHEVRE	0.53078	0.21556	1.00000	0.12360	0.42459	0.03523
	0.0011	0.0753	0.0	0.3116	0.0003	0.7738
OPUNTIA	0.15106	0.01572	0.12360	1.00000	0.03516	-0.07704
	0.2153	0.8980	0.3116	0.0	0.7742	0.5292
BOUC	0.28773	0.54982	0.42459	0.03516	1.00000	0.02131
	0.0165	0.0001	0.0003	0.7742	0.0	0.8620
AGNEAUX	0.05420	0.00510	0.03523	-0.07704	0.02131	1.00000
	0.6583	0.9668	0.7738	0.5292	0.8620	0.0

Table 18: Variation of Flock Size and Cash Flow for the Different Scenarios of Climatic Conditions (in % of Deviation According to Situation of Reference) in the Tunisian Community

	Flock size			Cash flow		
	W1	W2	W3	W1	W2	W3
	3 good years	3 bad years	3 bad years + limited employment	3 good years	3 bad years	3 bad years + limited employment
EA1	14.89	-18.14	-21.18	-4.60	0.30	5.70
EA2	5.04	-32.28	-51.14	7.67	-10.94	-8.21
EA3	7.10	-22.12	-27.47	5.70	-11.22	-25.85
EI1	69.10	-20.02	-46.48	10.44	-22.35	-44.18
EI2	4.28	-27.90	-62.97	2.90	-2.08	-28.05
EI3	42.26	-61.75	-63.17	17.16	-1.13	-12.11
Community	**10.83**	**-26.17**	**-34.86**	**5.98**	**-9.59**	**-20.13**

Table 19: Variation of Flock Size and Cash Flow for the Different Scenarios of Wage (in % of Deviation According to Situation of Reference) in the Tunisian Community

	Livestock			Tresory		
	WA1	WA2	WA3	WA1	WA2	WA3
	Monthly wage 300 DT	Monthly wage 300 DT + restriction of employment	Monthly wage 400 DT	Monthly wage 300 DT	Monthly wage 300 DT + restriction of employment	Monthly wage 400 DT
EA1	5.00	3.33	7.41	-0.31	4.10	1.54
EA2	19.41	21.55	39.35	5.29	5.72	10.56
EA3	13.02	12.87	28.43	13.80	13.68	26.97
EI1	20.47	69.86	55.20	3.80	10.31	5.43
EI2	1.92	23.82	5.48	2.84	5.43	4.76
EI3	16.03	47.18	32.64	-4.23	0.39	-2.21
Community	**13.45**	**17.40**	**28.72**	**9.57**	**10.42**	**19.22**

Table 20: Variation of Flock Size and Cash Flow for the Different Scenarios of off Farm Opportunities (in % of Deviation According to Situation of Reference) in the Tunisian Community

	Ewe stock		Cash flow	
	WL1	WL2	WL1	WL2
	50% employment reduction	75% employment reduction	50% employment reduction	75% employment reduction
EA1	-0.23	0.00	-0.33	0.00
EA2	-18.01	-7.91	-4.31	-1.74
EA3	-15.75	-4.65	-11.33	-6.06
EI1	-18.24	-18.24	0.50	0.29
EI2	-18.26	-8.64	-3.11	-4.47
EI3	-45.23	-12.87	9.88	4.96
commune	**-16.96**	**-5.80**	**-7.44**	**-3.99**

Table 21: Characteristics of farm types in Ait Ammar (Moroccan community)

Farm Type	Description	Number Farms	Av. Farm Size (ha)	Herd Size		Extraction level*	
				By farm	By type	By farm	By type
F1	Big mixte farms	23	25	79	1778	296	6671
F2	Multiactivity farms	110	14	14	1544	7	753
F3	Small mixte farms	171	6	12	2057	22	3818
F4	Small livestock producers	70	4	88	6195	816	57477
F5	Medium mixte farms	95	16	56	5320	397	37722
F6	Retired farmers	148	6	5	738	44	6435
F7	Herders settled in rangelands	11	0.5	78	842	1669	18030

Notes: * Forage unit per year

Table 22: Model results of Rangeland Management Options in Ait Ammar (Moroccan Community)

Tested options	Scenario Description	Community Income	Biomass 'left-overs'	Extraction level	
				Higher	Lower
Reference	Reference scenario	**10812165**	**2295**		
Technologies					
Rotation*	Rangelands grazed simultaneously between 2 plots	10857450	7245	All	
Fertilizers*	Biomass increased by 47%	10850540	1061	All	
Access restriction					
Goats	Goats forbidden to access the rangelands	10811963	9583	7,4,1,3	5,6
Cows	Cows forbidden to access the rangelands	10812165	8759	7,4,3	1,5
Grazing taxes					
Current system	1 DH/ovin, 2DH/bovine, goats forbidden	10809772	9867	1,3	7,4,5
Goat discriminant	1 DH/ovin, 2DH/bovine, 2 DH/goats	10808833	4396	3	7,4
Other options					
Quotas	10 heads per person fro 2 months	10808705	1513	6,2	7,4,5
Labor market	Labor opportunities created outside the community	24416590	0	1,4,6,2	7,5

Notes: * Creation of biomass is equivalent among the two options

Table 23: Variation in % of risk and income for each type of farm in Ait Ammar (Moroccan community)

	Expected value	Variance	T.A.D.	Legend:
EXP1	1.03	0.71	0.76	Expected value: ratio between the average income with
EXP2	1.07	1.17	1.00	insurance and the average income without insurance
EXP5	1.10	0.65	1.11	
EXP7	1.00	1.00	0.64	Variance: ratio of the income variance with and without
EXP6	1.05	0.57	0.52	insurance
EXP4	1.04	0.91	1.33	
EXP3	1.08	0.69	1.53	T.A.D. (total absolute deviation): the ratio of the sum of
EXPA	1.07	0.66	0.89	the absolute gaps of income with and without insurance

Table 24: Trend of the Insurance Demand with the Reduction of Subsidies in Ait Ammar (Moroccan Community)

% of public subsidies	Requirement in ha		Contributions	Reimbursements	Subsidies	F.C.N.
	level 1	level 2				
0.50	4670.37	112.89	440879.01	1124268.60	440879.01	242510.59
0.40	4670.37	112.89	529054.81	1124268.60	352703.21	242510.59
0.30	4670.37	112.89	617230.61	1124268.60	264527.40	242510.59
0.20	4662.74	112.89	704307.38	1122581.89	176076.84	242197.67
0.10	4661.82	112.89	792197.11	1125808.73	88021.90	245589.72
0.00	4661.81	112.89	880217.21	1128496.17	0.00	248278.96

Table 25: Impact of the Change of Insurance Premium in Ait Ammar (Moroccan Community)

Price			Demand		Farmers' contribution	Reimbursements	FCN
Level 1	Level 2	Level 3	Level 1	Level 2			
180.00	364.00	548.00	4661.81	112.89	880217.21	1128496.17	248278.96
198.00	400.40	548.00	4661.81	112.89	968238.93	1128496.17	160257.24
217.80	440.44	548.00	3421.06	112.89	794827.48	852432.34	57604.86
239.58	484.48	548.00	47.23	65.66	43125.12	72845.95	29720.83
263.54	532.93	548.00	47.23	65.66	47437.64	72845.95	25408.32
289.89	586.23	548.00	53.66	59.22	50275.27	70221.55	19946.27
318.88	644.85	548.00	112.89	0.00	35997.84	46058.30	10060.47
350.77	644.85	548.00	53.63	59.26	57023.91	70235.22	13211.31
385.85	709.33	548.00	112.89	0.00	43557.38	46058.30	2500.92
424.43	709.33	548.00	0.00	0.00	0.00	0.00	0.00

Table 26: Purchase price for sale's agents and farmers, respectively (Ait Ammar, Morocco) (in Dh/kg)

Types of feed	Purchase price for sale's agents (Dh/Kg)	Purchase price for farmers (Dh/Kg)
Bran	2	1.5-2.5
Barley grain	2	1.25-2.5
Pulp	1.9	1.7-2.3
Mixed feeds	2.1	2.5
Maize	2	

Table 27: Average Purchase Price and its Standard Deviation for the Farmers in Ait Ammar (Morocco) (in Dh)

	Bad year	Average year	Good year
Durum wheat (per qt)	416 [39.7]	325 [35.4]	257 [35.3]
Bread wheat (per qt)	393 [41.8]	225 [150]	238 [4.72]
Barley grain (per qt)	348 [106]	209 [71.4]	122 [17.4]
Straw (per bundle)	38.84 [12.44]		5.61 [0.99]
Bran (per qt)	255 [13.9]		142 [47.6]

Table 28: Purchase price of feeds for herders in the Zoghmar community (Tunisia) (in DT/kg)

Feeds	Good year	Medium year	Poor year	Very poor year
Barley grain	0.17	0.17	0.17	0.136
Straw	0.084	0.178	0.285	0.427
Hay	0.151	0.23	300	0.506
Bran	0.16	0.16	0.16	0.16
Cactus	0.022	0.02	0.022	0.028
Feed block	0.17	0.17	0.17	0.17

Table 29: Purchase Price of Feeds in the Sidi Frejd Community (Algeria) (in DA)

	Medium year (2003)		Poor year (1999)
	Average price	Standard deviation	Average price
Straw (/bundle)*	174.5	64.85	206-294
Barley (quintal)	1674	315.1	
Fodder (/bundle) *	235.6	49.4	
Bran (quintal)	1497	455.5	
Hay (/bundle) *	310.4	54.2	

Notes: * The bundle weights 17 kg in average

Table 30: Variation of Ewe Stock for the Different Scenarios of Barley Grain and Climatic Conditions (in % of Deviation with the Reference) in Zoghmar (Tunisia)

	A1 Barley price 19 DT/Qt	A2 Barley price 22 DT/Qt	A3 Barley price 19DT/Qt + dry years	A4 Barley price 22 DT/Qt + dry years
EA1	-15.21	-23.76	-28.86	-31.43
EA2	-4.11	-9.14	-7.40	-13.05
EA3	-0.90	17.69	32.30	30.02
EI1	0.00	0.00	-9.31	-31.71
EI2	-3.61	-7.89	-6.82	-30.49
EI3	-3.02	0.00	-13.79	0
Community	**-2.73**	**7.67**	**15.85**	**12.81**

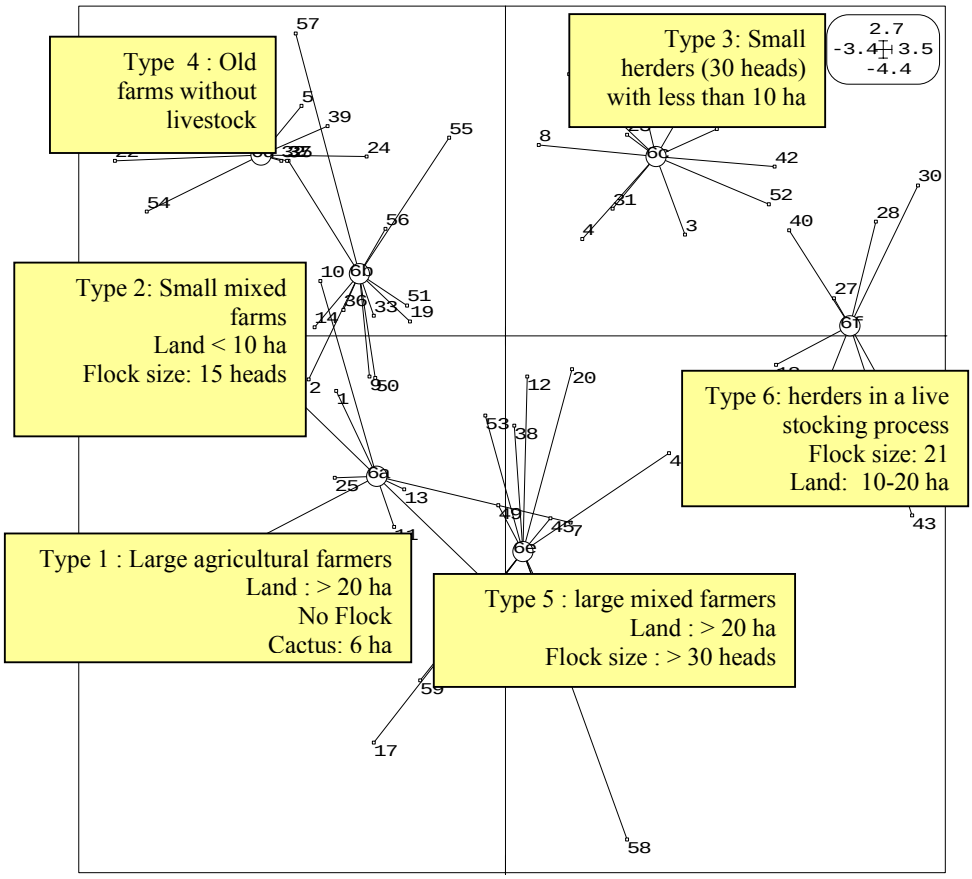
Table 31: Variation of Cash Flow for the Different Scenarios of Barley Grain and Climatic Conditions (in % of Deviation with the Reference) in Zoghmar (Tunisia)

	A1 Barley price 19 DT/Qt	A2 Barley price 22 DT/Qt	A3 Barley price 19DT/Qt + dry years	A4 Barley price 22 DT/Qt + dry years
EA1	2.52	15.74	23.91	15.63
EA2	-1.01	-1.90	15.05	12.92
EA3	-1.83	-7.72	2.00	0.66
EI1	4.90	15.10	11.80	15.34
EI2	1.31	1.85	-3.09	-2.69
EI3	6.30	13.85	1.63	-4.15
Community	**-0.59**	**-2.77**	**5.86**	**3.75**

Table 32: Variation of Ewe Stock, Cash Flow and Purchased Feed for the Different Scenarios of Liberalization (in % of Deviation from the Reference) in Zoghmar (Tunisia)

	Variation of ewe stock (in %)		Variation of cash flow (in %)		Variation of purchased feed (DT)	
	L1	L2	L1	L2	L1	L2
	Liberalization barley+ sheep	Liberalization feeds + sheep	Liberalization barley+ sheep	Liberalization feeds + sheep	Liberalization barley+ sheep	Liberalization feeds + sheep
EA1	-18.76	-29.17	42.00	36.27	-23.85	-24.99
EA2	10.63	5.22	1.77	0.54	4.09	0.04
EA3	25.48	22.05	4.26	2.11	10.95	8.22
EI1	0.00	0.00	-2.21	4.65	5.40	2.10
EI2	1.23	-7.68	-6.05	-2.45	23.82	11.60
EI3	-8.16	-22.33	3.56	6.35	20.83	12.98
community	**16.12**	**11.04**	**6.16**	**4.60**		

Annex 1
Presentation of the farm types in Sidi frej (Algeria)



Presentation of the farm types in Ait Ammar (Morocco)

Type 1. Big crop-livestock farms of Osibra. This type includes the Osibra farms managed by young (less than 45 years old) educated farmers that rely on crop-livestock activities for their livelihoods. Those farmers cultivate on average 20 ha and some of them rent out or share-crop extra land. It is a mechanized agriculture with the use of fertilizer. These farmers own 18 performing ewes (lambing rate greater than 1) and 3 cows on average. Animals are fed with bran, PSB and barley. Most flocks are conducted by a herder on the common rangeland.

Type 2. Multi-activity farms of Osibra. This type is characterized by Osibra farms relying on off-farm activity (wage work). The farmers are also renting out extra land or give it for share-cropping and have a relatively small flock that is confined to households leaving permanently on the rangeland camp (type 7). This farm type can be call 'wage-earners managing their farm assets'.

Type 3. Small crop-livestock farm. These farms are managed by 45 to 60 years old farmers. Assets consist in less than 5 ha of land and less than 10 TLU (including less than 6 ewes). Land is cropped with 50 to 75% of barley. However, those farms are mechanized and 1 to 2 hours labor per ha is used on cropland. Livestock are fed with straw, bran and PSB, have almost no access to rangeland, and generate a net income that does not exceed 20000 Dh/year.

Type 4. Small herders. This type consists of small livestock producers living in proximity of the rangeland. The representative household is composed of 4 to 8 workers, who cultivate less than 5 ha of barley with a labor productivity of 3 hours/ha. Flocks are composed of less than 6 ewes, with high turn over (30-80% exploitation rate). Rangeland is accessed less than 8 months in the year. Livestock is the main source of income; however the activity is not viable.

Type 5. Medium crop-livestock farms. These farms are located mid-way to the rangeland. Composed of 8 household workers on average, they cultivate more than 12 ha of wheat and barley. Cropping 'ways' are traditional, with the use of animal traction and fallow. Livestock assets comprise 10 to 20 TLU, which are mainly small ruminants. Animal productivity is low (lambing rate less than 1) and the exploitation rate is low (less than 30%) and rangeland is used by some flocks. Livestock income can represent until 75% of the total farm income.

Type 6. The retired. This type regroups farmers over 60 years old whom some of them benefit from a pension. The farms are located in the same part of the commune (opposite to the rangeland), own very little livestock and cultivate 2 or 3 plots with cereals by using occasional paid labor.

Type 7. Tmoutira households. This group is characterized by young herders who are located permanently on the rangelands camp and are living from guardianship or herding contracts. Some of them own a flock composed of 6 to 11 ewes, in addition to few goats. Animals graze all year round with complementation ration composed of straw, PSB and bran. Exploitation rate is low.

Presentation of the farm types in Zoghmar (Tunsia)

Young producers (EI2)

The type EI2 gathers young farmers (35 to 45 age years old). They own less than 15 ha with 1-2 ha in the irrigated perimeters. Olive trees occupy the rainfed areas and cactus the marginal cereal land. They cultivate intensively the irrigated areas with vegetable crops like tomato, melon, etc. To fund their agricultural activities, they often work as casual workers. The livestock activity is reduced to less than 10 ewes. The animal performances are low with less than 0.95 lambs per ewe and per year. These farmers haven't specific feeding strategies to reduce the impacts of droughts. Their main objective is to intensify the cropping system with the introduction of new crops in the irrigated areas.

Sedentary pastors or agro-pastors (EA1, EA2)

EA1 and EA2 types group all the farms which are mainly oriented to livestock activity. The ratio number of ewes/agricultural area is the highest and the total agricultural area ranges between 23 and 40 ha. If the sheep herd occupies the dominant place with more than 60 ewes, this type of farm counts also she-goats and cattle (between 1 to 4 cows). The cows cover the family milk requirements; the she-goats regulate the cash flow during the year, especially in summer. Sometimes, some farmers buy a veal calf which is bred under the mother. The feeding system is mainly based on barley straw and grain, hay, bran and cactus during drought years. These groups register good animal performances with more than 1.1 lambs per ewe and per year. The cultivated area is planted with barley for animal and durum wheat for family self consumption. It is observed that around 60% of used land is in jointly-owned property.

In this class, it is distinguishes two sub-groups:

1) The pastors (EA1) who affect the majority of land to barley and cactus (more than 8 ha is planted with cactus). This group has adopted the technologies introduced by the ICARDA project (M&M) such as the introduction of improved rams and the cactus to improve the animal performances.

2) The diversified agro-pastors (EA2) who affect more than 8 ha to durum wheat and 5 ha to olive trees, mainly as edge.

The mixed agricultural livestock systems with off-farm activity (EI1)

These farms are the largest agricultural farms with more than 50 ha and 3 ha are located in the irrigated perimeter. The main source of funding to invest in agriculture comes from off-farm activities. These are large families with more than 10 members, 7 at school. This class benefits also from bank credit. They are well-equipped with a tractor and a car.

The irrigated area is mainly affected to fodder crops (oats, sorghum) and cereal crops (barley and wheat) to cover the feed requirements. The average herd size is between 20 to 52 ewes. But these farmers don't register high performances with a productivity of 0.95-1.05 lambs/ewe/year.

The diversified herders (EA3, EI3)

These farmers have less than 9 ha without any property rights. The area is mainly affected to barley. These farmers have a diversified herd with 10 to 20 ewes and 5-8 she-goats. With a small family and without any other source of funds, the schooling rate is the lowest.

In this class, two sub-groups may be distinguished:

1) The old herders –with more than 65 years old- (EA3), who devote their own small piece of land to the livestock. They register the best animal performances with a low use of hay and an important use of cactus in the feeding system.

2) The diversified herders (EI3) who have ewes and goats.

These two groups are seen different during the dry years: if the group EA3 de-stocks, the second group EI3 tries to keep his herd by increasing the cactus ration and temporary off farm activities.