FEMISE RESEARCH PROGRAMME

Community Level Impacts Of Policy, Property Rights And Technical Options In The Low Rainfall Areas Of West Asia And North Africa

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CHAPTER ONE

COMMUNITY MODELING STUDIES IN DRYLAND AGRICULTURE: AN INTRODUCTION

1. BACKGROUND AND RATIONALE

Governments in the WANA have long intervened in their domestic agricultural markets and have used various schemes to influence their relation with international agricultural products. While very few estimates of the cost and benefits of these agricultural policies are available, agricultural budgets are being substantially revisited because of the burden these policies place on government expenditures. Government interventions, mainly through guaranteed prices, input subsidies and trade barriers though tariffs, quotas and public trading monopolies, impose not only substantial costs on consumers and taxpayers, but also generate distortions in the domestic market and trade, reduce economic efficiency at the national level and often lead to negative effects on the environment. Aware of these problems, a few governments have initiated reforms of their agricultural policies. But progress towards achieving these reforms has been slow at best when reforms are not overturned because of internal pressure. For example, progressive reductions in input subsidies (mainly for animal feeds) reached during the implementation of an agricultural structural adjustment program are quickly annihilated at the advent of the first drought year. Governments tend to lose on two fronts. They have to keep the old subsidization or protection system but honor at the same time any new system designed as an alternative.

Difficulties encountered by the agriculture system in WANA have lead researchers and policy-makers to examine in more details the performance of agricultural policy in the context of the current Arab and Mediterranean environment. First, agricultural policy does not appear to be transparent. While the policy objectives tend to be relatively clear as they are mostly related to increases in production and food self-sufficiency motives, the costs, benefits and beneficiaries are not always easily identifiable because of a combination of special interests involved and the limited capacity of a public or independent research system to evaluate the impact.

Second, agricultural policy is seldom targeted to specific outcomes or recipients, or tailored to provide efficient transfers to achieve those outcomes or reach the intended recipients. Price guarantees are provided to all producers regardless of the production system they follow. Consumers benefit from large subsides for bread, cooking oil, sugar and other foodstuffs irrespective of their level of income or wealth. Livestock owners receive the same feed subsidy regardless of their herd size, their location or their feeding practices and resource use. Though exceptions could be mentioned, the overwhelming practice in WANA is that of generalized support systems. Third, sectoral policies in agriculture while flexible in appearance and designed to reflect the diversity of agricultural situations fail to respond to changing objectives and priorities and are often applied beyond the time period needed for the specific outcome achieved as it is the case for most feed subsidization and drought relief programs. Fourth, policies are rarely equitable in taking into account the effects of the distribution of support between sectors, farmers and regions.

It must be mentioned however, that the failure to achieve the above characteristics sought in the nature of agricultural policy, efficiency, transparency, targeting, flexibility and equity is not specific to the WANA region or other developing countries. Though substantial reforms have been achieved in developed countries, there is considerable scope for further improvements as evidenced by the results of a series of studies conducted by OECD (2000a, 2000b, 2000c) not only for the member countries but also non-members, and highlighted in a recent policy brief by OECD (2000d).

There has been an emphasis in the current discussions on agricultural policy reforms worldwide on a number of issues that are of a particular concern to the WANA region and with direct relevance to the situation of the low rainfall areas. Policy reform, taken in its broadest sense involves "…a progressive and concerted reduction of agricultural support and a shift away from measures linked to production or other factors of production…" (OECD, 1998b). The definition of reform could also be extended to those measures that are linked to output restrictions either to put an upper limit on production, as it is currently the case in some developed countries or to secure a minimum level of output in developing countries faced with domestic shortfalls. Some of the WANA countries are still linking support for example to particular output restrictions for what is referred to as “strategic” commodities. In addition to reforms in production-linked support, new concerns of a social or environmental nature are being added to the process of reform. Three main issues in this process merit attention. They are related to the extent of agricultural support, the distribution of this support and the relation between agriculture and the environment. These issues have important implications in terms of sustainable development because of their impact on the three corners of the “critical triangle”.

The impact of agricultural policy on rural development is often assessed in terms of (i) its effectiveness in raising or at least maintaining rural incomes and employment and (ii) its success in achieving supply growth goals. In developed countries, there is evidence that output related agricultural policies have positively contributed to maintaining the socio-economic strength of rural areas while at the same time influencing the level and mix of agricultural output and resources utilized for its production. However, the question has been raised about whether the impact is wholly positive, cost effective and whether this trend is sustainable over time (OECD, 1998c, p. 69-72). The overall assessment is that despite the potential positive contribution of agricultural support policies to the rural economy, the positive effects have been offset by an increasing rural exodus trend, the widening of disparities in the agricultural sector and in the rural areas and the substitution of labor-intensive farming methods by more capital-oriented production techniques. Agricultural support has not been cost-effective when it comes to the maintenance of farm incomes in the sense that less than one-third of what is spent on support programs results in additional farm income, and an even smaller proportion results in a net increase in farm household income according to an OECD study on the relative efficiency of agricultural policy instruments commonly used in OECD countries (OECD, 1995). It is also very unlikely that these patterns could be sustained against a background of technological innovation, increased productivity, globalization and changes in consumer preferences as governments will be required to increase the level of support just to maintain the status-quo. This is not only the case in developed countries. Countries in the WANA region are facing similar challenges in the sense that trends in crop and livestock production are being artificially maintained at levels beyond the productive capacity of land resources, and achieved with limited increases in productivity (low levels of technology adoption) without substantial increases in net farm income via the market price support multiplier effect.

The second main issue of a particular concern in the discussion on agricultural policy reform is related to the distribution of support. Pricing policy interventions in the form of market price support of input subsidies viewed as transfers to the agriculture sector have raised concerns about the resulting income distribution effects. Studies conducted for developed countries have provided limited justification for the use of agricultural support as a mean to reduce income disparities among farms of different types and sizes, and among regions or even agro-ecological zones. Has support been equitable and has it been cost-effective in transferring income to the intended recipients? Again, here, the record of agricultural support schemes is negative overall. Studies have found that the concerns about the effects of government transfers on income distribution were not unfounded. An OECD evaluation (OECD, 1999a) shows support is inequitable since the distribution of support is close to the distribution of output, with the largest, and hence the most prosperous farms, being the main beneficiaries. It was also noted support tends to increase income disparities between farm types. In some countries, the fact that support, as a whole is concentrated on the largest farms was viewed as a reflection of an implicit policy objective to promote the concentration of landholdings. Small farms tend to receive only a small proportion of the total support although they need the support more than the large farms. There is limited empirical work on this issue for the WANA region looking at the distribution of support on the supply side as most studies tend to be related to the efficiency of consumer subsidization programs. For example, Ayadi and Matoussi (1999) have analyzed the spatial and temporal dimensions of poverty profiles in Tunisia and found that the removal of subsidies on cereals and vegetable oil could hurt more the poor people in the rural areas than in the urban areas.

Relation between the environment and agriculture is the third concern in the recent discussions on agricultural policy worldwide and particularly in WANA (Chaherli et al., 1999). Assistance to the sector has distorted production and consumption incentives and has consequently amplified the negative or positive impact of agriculture on the environment. There is no doubt that the level of support and its administration has an influence on the current land use practices and livestock production methods and contributes to the kind of environmental impact observed and degree of resource use. The experience of developing countries and a number of emerging and transition economies show that the reduction of output support and the lowering of input subsidies have generated in many cases a double benefit (OECD, 1998b). The first benefit stems from more efficient allocation of resources in agriculture. The second benefit comes from the reduction of negative and the enhancement of positive environmental externalities. For example, agricultural policy reforms have lead to the slowing down of the conversion of fragile lands into agricultural uses and a move out of crop production in favor of grazing and forage production. The grass or tree cover established in these fragile lands has helped to put a stop on land erosion and in some cases overturn soil erosion trends. In the livestock sector, some positive outcomes haves also been reached as reform has pushed farmers to keep small animal herds and lower stocking densities with positive environmental consequences such as reduced grazing pressure and manure excesses, lower soil erosion and nutrient leaching.

While it was recognized that the removal of support in the agriculture support could cause not only environmental benefits but also hardship, the current thinking tends to be directed towards compensation for those who might suffer as a result. This, for example, could be done though selected and targeted financial incentives for farmers who would agree to in return to adopt environmental friendly farming practices. The ban of barley cultivation in Syrian rangelands is an illustration of a policy reform that generates environmental benefits. However, the difficulties faced by livestock owners, especially those with limited adaptation capabilities, could provide grounds for targeted compensation. The compensation could be intended to pay farmers for providing environmental services in excess to those provided by adhering to sound livestock and rangeland management practices.

A number of agricultural policy studies have analyzed the situation of WANA countries, but they have not given adequate evaluation of the microeconomic impacts of reforms, the combined effects on different dimensions of sustainable development and in particular on the equity and environmental sustainability dimensions. While governments in the region have started orienting agricultural policy towards greater reliance on the market, very little is known on how farming systems in dryland agriculture have adjusted and will be coping with further changes in the policy environment. Researchers as well as policy-makers in WANA would benefit from a prospective study of how pricing policy reforms simultaneously affect the three dimensions of sustainable development.

The research presented in this report will examine two case studies of the impact of pricing policy reforms in rainfed agriculture. First, we present the research approach to assess the micro impact of reforms at the community level. It uses quantitative analysis to evaluate the impact of different policies on rural income and examine the social and environmental implications of the resulting changes in the Sidi Frej community (Algeria) and the Falha community (Jordan) from an ex-post standpoint. Chapters 2 and 3 present the modeling structure used for the two case studies. Second, an inter-country comparative study is undertaken and focuses on some major differences and similarities in the impact of pricing policy reforms for the sites selected in the case studies. The main purpose of this synthesis section is to be able to draw relevant implications at the regional level (Chapter 4).

The remaining part of this chapter covers in Section 2 an overview of studies that have looked at the impact of policy on agriculture using tools similar to the one developed in this study. Section 3 looks at specific conceptual and analytical considerations related to the modeling approach before exploring in Section 4 the general features of the model used in the country studies and the methodology followed. Section 5 paves the way for the country studies and cross-community comparison synthesis by outlining the objectives of the work.

2. PAST RELATED WORK: QUANTITATIVE ANALYSIS OF FARMING SYSTEMS FOR POLICY FORMULATION

There is growing interest in the field of policy analysis with the aid of farming systems modeling in agriculture. The increasing need to undertake and disseminate research in this area has been recognized among other endeavors by a special issue of the journal Agricultural Systems (Vol. 58, 1998) entirely devoted to the use of quantitative land use models for policy formulation. With a momentum moving away from government deep involvement in agriculture, including in the developing world, needs have been expressed not only in national research systems but also in governmental agricultural policy research units to evaluate the impact of past and current policies and increase the transparency in future policy formulation. This obviously requires scientific tools that can be used to explicit the trade-offs among various policy objectives and reduce the uncertainty on the effect of potential policy reforms. A number of studies are particularly relevant to the line of work presented in Part I of this book.

Van Keulen, Kuyvenhoven and Ruben (1998) review the major changes that have taken place in the past decade, with regard to the available policy instruments for food security and rural development in the context of structural adjustment programs carried out in the agricultural sector. They also discuss the linkages between agricultural policy and farmers' supply response by emphasizing the influence of macro-policy for decision-making at the micro-level of a farm household. To analyze these linkages, they propose an integrated bio-economic modeling framework that allows a better understanding of the effects of macro and sectoral policy interventions for food security and sustainable land use at different levels of aggregation for the farm to the regional level.

Van Ittersum, Rabbinge and van Latesteijn, focus on their side on exploratory land use studies and their role in the phase of formulating strategic policy objectives. They state that exploratory land use studies contribute to a transparent discussion on policy objectives by showing ultimate technical possibilities and consequences of imposing different priorities to agro-technical, food security, socio-economic and environmental objectives. The methodology they present confronts science-driven technical information to value-driven objectives under given values of exogenous variables (e.g. regarding population growth and requirements for agricultural produce). For example, the land use scenarios generated show consequences of different priorities for objectives by using natural resources and technical possibilities in different ways.

Ruben, Moll and Kuyvenhoven present an integrated bio-economic modeling framework for the simultaneous appraisal of agro-ecological and socio- economic parameters. Implications of this integrated approach are analyzed against the background of policy discussions on land markets, incentives for innovation, and public investment for agricultural intensification. Though this type of analysis, they find that policy analysis for sustainable land use is critically dependent on the specification of the linkages between decision-making procedures regarding resource allocation by farm households and their supply response to changes in the economic and institutional environment.

Hengsdijk, van Ittersum and Rossing (1998) add consumption decisions to the standard production based farm model and integrate agro-technical knowledge with socio-economic insights to analyze the impact of various output and input pricing policy reforms on two farm types in South Mali in a cotton producing area. They found that while the impact of these policy changes is positive in terms of income growth, environmental sustainability indicators show an ambiguous effect. The study also indicates that access to environmental-friendly technologies is the most crucial factor for land resource conservation.

Bade and Kruseman (1998) present their own approach to bio-economic modeling and assess the effectiveness of different agrarian policies to improve farm household income and soil fertility. Farm household decisions on allocation of land, labor and capital resources for crop and production technique choice are simulated, taking into account resource availability, household objectives and prevailing market conditions. The modeling framework combines two levels of analysis: farm and region. With regional aggregation, prices are determined endogenously on regional markets. The approach is applied to the Cercle de Koutiala in Mali, with results indicating that technology alone cannot sufficiently induce farmers to adopt sustainable production systems if additional economic incentives are not provided.

An important line of research on community and bio-economic modeling has been initiated and implemented at IFPRI to simulate the impact of changes in agricultural technologies, policies and/or institutions on resource use patterns, growth and poverty alleviation. For example, Barbier (1996) simulates a village's response to population and market pressure with the aid of linear programming model combined with a bio-physical model of soil condition and plant growth. Calibrated for two villages located in a semi-arid and a sub-humid savanna region in Burkina Faso, the model has been used to isolate the main factors of agricultural intensification and distinguish between effects caused by population pressure and those driven by market condition changes. Similar structures have built to explore the same kind of issues in other parts of the world. For example, Barbier and Bergeron (199?) evaluate the effects of population pressure, market integration, technological improvement and policy decisions on natural resource management in the hillsides of Honduras. The simulation results confirm that technology improvements such as irrigation and new varieties can help overcome diminishing returns to labor due to population pressure.

Population increases in the village of La Lima had only a small effect on the condition of natural resources because the cropped area increased only slowly thanks to the intensification of production. The model confirms however that the relationship between population growth and natural resource condition has a U-shaped structure.

Senahoun , Huidhes and Deybe (1998) use also a bio-economic model to assess the impact of structural adjustment policies on soil erosion in Northern Benin.. Their main conclusion is that the implementation of structural adjustment policies appears to have led to a more sustainable agriculture in the study area, a major cotton-producing region in Benin. Their results show that the reduction of soil loss was mainly due to an increased use of fertiliser, which may have had a positive effect on the soil nutrient balance. Therefore, the improvements induced by institutional and policy reforms in the input and credit markets may have contributed to a more sustainable use of land resources.

Deybe (1998) uses a more regional based model to analyze the policies undertaken after the devaluation of Franc of the African Financial Community (FCFA) in Burkina Faso. The results show the impact of the policy followed (actual) is positive for farmers as well as urban consumers; the impact of a liberal policy will be favorable for the agricultural sector of all regions, but it will be limited if there is no urban income growth, and the impact at the consumers' level will be very negative, especially for poor households; the last simulation looks at an open market for fertilizers scenario and leads to a positive outcome for all regions.

While bio-economic and community modeling has been extensively carried in Latin America and Sub-Saharan Africa, very few applications could be found for the WANA region despite the existence of widespread rural poverty and resource degradation. Nordblom and others at ICARDA have developed whole-farm models to analyze the impact of medic pasture introduction or livestock based technologies (Nordblom et al., 1992). The main feature of the modeling work conducted at ICARDA is that it takes a whole-farm approach integrating the different components of the farming system prevailing in dry areas. By integrating annual crops with sheep and natural pastures, the approach allows the interaction between the different components, a process representing the essence of crop-livestock production in low rainfall environments. It contrasts with that usually adopted in the WANA region where the discipline or commodity approach prevails.

The studies surveyed show that the development of an understanding of the income growth, equity and environmental sustainability implications is critically important to understanding the process of decision-making in agriculture. Because of the linkages between the different outcomes or objectives of policy reforms, impacts have to be examined not only in one dimension separately, but also in two or three dimensions simultaneously. It is this simultaneity that characterizes to a certain extent the concept of sustainable development, a concept in which a lot of efforts have been put in the 80's and 90's in trying to define. An emphasis has been put on acceptable definitions but less so on trying to look at the impact of poverty and growth on environmental degradation and vice versa. Goals are often cast in terms of internal contradictions between the goals of growth and poverty alleviation, and environmental sustainability. The limited availability of theoretical models and empirical evidence on the potential impacts of international, macroeconomic and sector policies to bring socially desired outcomes on all fronts tend to add to the overall sense of frustration felt by many policy-makers. Faaland and Krηksen (1991) summarize well the situation:

> *"...Important knowledge gaps remain regarding the factors that create and condition these links, and to what extent these links can be exploited to* <u>*reverse*</u> *current trends in natural resource degradation. For example do rising levels of poverty or agricultural growth worsen degradation? In those situations, does environmental degradation, in turn, limit prospects for poverty alleviation and/or agricultural growth in the future? If so, why and how? Can we expect poverty alleviation (however achieved) to reduce environmental degradation? Finally, but most importantly, what is the role of policy in altering and/or exploiting these links to simultaneously achieve objectives in all three outcomes? Pinning down these causal links, their direction, and the mechanisms through which they work, is critical for policy intervention to succeed..."*

On another front, researchers on Latin America have demonstrated how market-friendly measures in key policy areas can simultaneously spur growth and improve income distribution (Birdsall, Graham, and Sabot, 1998). By identifying win-win strategies, authors of several studies challenge the conventional wisdom that there is always a tradeoff between these two objectives. The type of macroeconomic reforms implemented in Latin America is claimed to have provided opportunities to increase both efficiency and equity in many sectors including agriculture. A case is made on the relevance of new ways of reducing inequality, not by growth-inhibiting transfers and regulations, but by enhancing efficiency—eliminating consumption subsidies for the wealthy, increasing the productivity of the poor, and shifting to a more labor and skill-demanding growth path. While this strategy could work as well in agriculture, Carter and Coles (Chapter 6 in op. cit.) note that because of the market imperfections found in the rural economy, the removal of subsidies and other market distortions is not enough to achieve growth without worsening income distribution.

This section has tried to review some of the approaches that look at the different dimensions of sustainable development. We have focused on the studies that tend to link the concept to policy interventions with implications for the agriculture sector as a whole, and the well being of people and resources in particular. The next section show how different pieces from the different quantitative approaches just presented are used to evaluate policy reforms and its impact in the low rainfall areas of the WANA region.

3. MODELS AND METHODOLOGY

The models on which the studies presented in the previous section are based on the technique of mathematical programming (MP). MP applications in agriculture are extensively described in references such as Hazell and Norton (1986) or McCarl and Spreen (1999). MP refers to a set of procedures dealing with the analysis of problems in which an agent (say a farmer) wishes to optimize a measure of wealth or satisfaction by selecting values for a set of decision variables subject to some constraints dictated by the environment and beyond his/her control.

The modeling approach adopted in the country studies consist of the following four components: (i) a farm-household model that specify the underlying behavioral relations regarding farm household resource allocation and consumption priorities; (ii) an input-output model for crop and livestock activities that specifying the technological coefficients for current and potential activities; (iii) a mathematical programming optimization procedure to evaluate the farm household response to changes in the market environment (e.g. changes in policy instruments);
(iv) an aggregation procedure to address the exchange of individually owned factors of production (land, labor and capital) and the access to common resources at the community level.

The community model represents an abstract and simplified picture of an aggregation of typical whole-farm systems found in drylands. The smallest unit of analysis is the farm, which is assumed to have minimum cash requirements to be met by crop and livestock income or off-farm employment either within or outside the community. Farm families have different resource endowments for crop-livestock production in terms of land, labor and capital. The individual farms are linked not only between themselves in terms of exchange of factors of production but also to the market for input purchases and output sales.

The model used in the community studies relies on a standard mathematical programming formulation of the type:

$$\begin{aligned} &Max\ \overline{C}X \\ &s.t.\ AX \le ?b \\ &X \ge 0 \end{aligned}$$

where ***c*** is a vector of net average returns, ***A*** a matrix of input-output coefficients, ***b*** a vector of resource endowment levels and ***X*** a vector of decisions related to land allocation, and input use for crop production, sales and purchases of animals, sales and purchases of feed, labor allocation and financial farm management. This general formulation has been adapted to incorporate the features described next.

Farmers in the community model have been grouped into farm types. Rather than maximizing the objective function with Total net revenues ***TR*** for all farmers in the sample or population:

$$\begin{aligned} &Max\ TR = \sum_i \pi_i \\ &i = 1, 2, \ldots, k \end{aligned}$$

We have maximized a weighed profit function where the weights α_j represent the importance of each farm type (the frequency of which is n_j) in the sample or population of size ***N***. The total number of types ***h*** has been chosen such that h<<k to signify that we are taking only a limited number of farm types (usually between 3 and 7). This procedure is justified on computational and policy recommendation grounds.

$$Max\ TR = \sum_j \alpha_j \pi_j$$

$$j = 1, 2, \ldots, h$$

$$\alpha_j = \frac{n_j}{N}$$

First, while computational progress has been made with the current computer technology, it is still cumbersome to build model for each farmer in a community given the level of complexity reached by the current structures of the model and the numerous dimensions taken by the decision variables. Second, with the understanding that policy is designed to fit a larger scale of implementation than the farm level, the use of policy recommendations is warranted only when farmers are clustered according to similarities within the same class and differences across classes when it comes to characteristics such as the production system used or the level of resource endowments. While there is recognition that the process of aggregation has its limits, the benefits of an analysis for farm types tend to outweigh the costs related to information loss.

The clustering into farm types was conducted by identifying relatively homogenous groups of farmers based on selected characteristics and attributes related to socio-economics, resource endowment, behavior and agro-ecological conditions. These key discriminative variables were identified on the basis of a detailed analysis of household survey data. The process was done using the SPSS hierarchal cluster analysis (SPSS, 1985)[1].

To capture crop-livestock integration, an important feature in the production system found in arid zones, the crop output has been distinguished into three components to capture the joint product nature of crop production. The output vector for each crop k was specified as:

$$Q_k = Q_k(q_{grain}, q_{straw}, q_{stubble})$$

This distinction is important as crop production (type of crops and varieties) are very much related to the qualitative and quantitative feed needs for the herd as well as herd composition. The feeding strategy was specified in the following way[2].

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[1] More details on the specificities of the procedure and the model are reported separately in the country community model description.

[2] We use the general formulation as in McCarl and Spreen (1998) for a feed mix problem and adapt it to the small ruminant nutrition context in low rainfall environments. We have ignored calcium and

Let's define an index (i) to represent the nutritional characteristics which must fall within certain limits (1 = dry matter, 2= crude protein, 3 =energy), an index (j) which represents the types of feed available either from the farm or purchased from the market or accessed through monetary or non-monetary contractual arrangements (e.g. pastures), and an index (l) for each type of animal in the herd (disaggregated by sex, age and type) and (s) the season during which the farmer takes his/her decision. Then let us define a variable (***C_{jls}***) to represent how much of each feed is used in the diet for each animal type. The constraints of the problem include two types of constraints: one set for the minimum requirements in terms of energy and protein, and one set for the maximum requirements for dry matter. Two sets of parameters are needed to setup the feeding system according to feed origin and nutrient composition. The first block of parameters a_{ij} is the amount of the i^{th} nutrient present in one unit of the j^{th} feed ingredient. The second block has the maximum dry matter ***DM_{ls}*** , the minimum energy amount ***ENE_{ls}*** and the minimum protein amount ***PRO_{ls}*** to be fed to each animal type (l) and by season (s). Then the feed composition constraints are formed by summing the nutrients generated from each feed (a_{ij} C_{jls}) and requiring these to exceed the minimum energy and protein levels or to be less than the maximum dry matter to be fed to each animal type. The resultant constraints are:

$$\sum_j a_{1j} C_{jls} \leq DM_{ls}$$

$$\sum_j a_{2j} C_{jls} \geq ENE_{ls}$$

$$\sum_j a_{3j} C_{jls} \geq PRO_{ls}$$

Risk and uncertainty are important factors in dryland agriculture because of agro-ecological factors. In addition to the crop and animal production risk arising as a result of weather and performance based factors, pricing policy and institutions tend to modify the nature of price risk faced by farmers in the LRA. In order to incorporate the nature of agricultural decision making under uncertainty, the conceptualization of decision problems under risk in low rainfall environments was done through various formulations developed and tested in the area of risk and

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phosporus needs as these tend not to be critical in the nutrition system analyzed.

uncertainty. In the two community studies, the Mean-Variance (EV) approach and the Target-MOTAD approach[3] have been selected to represent risk and uncertainty in the community models. In the community model for Jordan, the EV specification was formulated as:

$$\begin{aligned} & Max\ \ Z \ = \ \overline{C}\mathrm{X} \ - \ \Phi\, \mathrm{X}'\, S\mathrm{X} \\ & s.t.\ \mathrm{AX} \ \leq \ b \\ & \ \mathrm{X} \ \geq \ 0 \end{aligned}$$

The estimate of the risk aversion parameter was such that the difference between observed farming behavior and the model solution is minimized (as done in other studies such as Brink and McCarl (1979) or Hazell et al. (1983)) while S is an estimated variance-covariance matrix for jointly generated crop and livestock returns.

In the Algerian case study, risk was introduced via the Target-MOTAD formulation developed by Tauer (1983) by incorporating a safety level of income while also allowing negative deviations from that safety level.

$$\begin{aligned} & Max\ Z \ = \ \sum_j \overline{c_j}\, \mathbf{X}_j \\ & s.t.\ \sum_j a_{ij}\, \mathbf{X}_j \ \leq \ b_i \ for\ all\ i \\ & \sum_j c_{kj}\, \mathbf{X}_j \ + \ Z_k \ \geq \ T\ for\ all\ k \\ & \sum_k p_k\, Z_k \ \leq \ \lambda \\ & \mathbf{X}_j,\ Z_k \ \geq \ 0\ for\ all\ j,k \end{aligned}$$

In this specification, p_k is the probability of the k^{th} state of nature; T is the target income level; Z_k is the negative deviation of income, allowing income under the k^{th} state of nature to fall below target income; and λ is the maximum average income shortfall permitted. The equation with the target income level T on the RHS gives the

[3] See Hazell and Norton (1986) or McCarl and Spreen (1998) for a description of various risk specifications in agriculture.

relationship between income under the k^{th} state of nature and a pre-determined target income level. The variable Z_k is non-zero if the k^{th} income result falls below T. It is the constraint with the right hand side of λ that limits the average shortfall. In this kind of risk specification, the model has two parameters related to risk (T and λ), which must be specified[4].

The bio-economic problem in the context of crop-livestock integration in the two community studies was analyzed by combining mathematical modeling with computer analysis with the aid of a high-level modeling language, GAMS, a General Algebraic Modeling System, first developed at the World Bank in the late 1970's. The system as presented in Zenios (1996) provides an algebraic language for the representation of large and complex systems[5], as it is the case for the modeling of a rural-based community. It allows the definition of algebraic relations to link variables with equations and the use of a data management system to incorporate socio-economic and bio-physical information into the model structure. The models are calibrated using the Positive Mathematical Programming (PMP) approach as described in Hazell and Norton (1986). The baselines have been obtained in such a way that the models in the initial runs replicate actual figures in terms of production activities (crops, livestock and labor) and level of income.

4. OBJECTIVE AND SUMMARY OF COMMUNITY STUDIES

In a 1994 Expert consultation on the management and sustainable development of drylands in the Arab world (Aleppo, Nov 1994), one policy recommendation presented in a paper on rangeland and livestock development (FAO-RNEA, 1994, p.3) states that "…trade, exchange rate and price distortions should be removed to provide better incentives to livestock producers…". The paper concludes that livestock production in dry areas (marginal lands and rangelands) is under threat and that immediate action is needed to secure a sustainable development path for the people living of livestock in these areas. While these concerns are legitimate, there is to date

[4] More details on the practical aspects of the specification for the model used are provided in the case study chapters.
[5] See Zanios (1996) for an overview of the GAMS modeling language and some applications.

very limited prospective empirical evidence that could support the claims made about the danger faced by livestock producers and farmers in arid zones.

This research tries to fill the void by investigating in an ex-ante framework how market-oriented agricultural policy reforms discussed in government forums could affect agricultural production, the lives of the rural poor and resource condition in the low rainfall areas of WANA. The study focuses in particular on the effects of reduction in input subsidies and output price support in the crop and livestock sectors. The research addresses some questions related to the three themes discussed in the introduction:

- What are the potential impacts of reforms in terms of market support and input subsidies on agricultural production and resource use?
- In the presence of feed subsidies, how effective has this policy been in efficiently targeting the farmers that need it the most? How does the removal of this kind of subsidies affect different farm groups and what are the likely income distribution effects of this kind of reform?
- What are the implications of lower output support and input subsidies in terms of the environment? Does the removal of less distorted output and input markets lead to positive environmental externalities?
- If liberalizing crop and livestock markets turns out not to be enough to promote one or more dimensions of the critical triangle, what kind of complementary policies should be recommended to mitigate the negative impacts?

The research attempts to analyze decisions of rural households that are quite heterogeneous in terms of wealth, and access to credit, technology, and input and output markets. The analysis is based on two community models, constructed from the results of various household surveys conducted in the communities of Sidi Frej and Falha. This research is expected to add to the understanding of how agricultural pricing policy reforms could potentially affect the dryland agriculture in WANA. It is hoped to help identify additional operational policies and investment strategies that could be used to simultaneously spur growth, improve income distribution and reduce resource degradation.

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CHAPTER TWO

COMMUNITY MODELING PLATFORM FOR AGRICULTURAL POLICY EVALUATION AND SIMULATION IN ALGERIA (COMPESA)

The linear programming model COMPESA of the Sidi Frej community consists of several groups of constraints or equations (representing a total of 12031 single equations). In this section a complete specification is given. The symbols used are defined in three tables following the equations: indices in Table 1, coefficients in Table 2 and variables in Table 3. The model is multi-periodic (four seasons) and has a recursive nature in the sense that the optimization process is done on an annual basis with the stocks carried over to the next year over a 10-year planning horizon.

The objective function is meant to represent the wealth generated by the various farm types in the community.

$$Max\ REVENUTT = \sum_{f} NUMB_f\ REVENUE_f$$

Total wealth is calculated as the weighted average of wealth for the 6 classes of farmers where individual wealth is the net value of production, less input costs (including variable chemical inputs, labor and capital) , plus off-farm work labor income. All monetary values are expressed in *Algerian Dinars* (DA).

$$
\begin{aligned}
& REVENUE_f = \\
& + \sum_c\sum_e\sum_t SUP_{cetf}\ MB_{cet} + \sum_c\sum_e\sum_t transvent\ \ SUPLOC_{cetf}\ \ MB_{cet} \\
& + \sum_c\sum_e\sum_t SUPasso_{cetf}\ \ transvent\ \frac{PB_{cet}}{2}\ - COUT_{ct} \\
& + \sum_c\sum_e\sum_t transvent\ \ SUPassod_{cetf}\ \ transvent\ \frac{PB_{cet}}{2} \\
& - \sum_c\sum_e\sum_t transacha\ \ SUPLOC_{cetf}\ \ PRIXLOC_e \\
& + \sum_c\sum_e\sum_t\sum_a SUPP_{cetfa}\ \ MBPA_{ceta}\ + \sum_c\sum_e\sum_t SUPPREA_{cetf}\ \ MBP_{cet} \\
& + \sum_c\sum_o\sum_e\sum_t 0.5\ (COUTM_{coet}\ \ SUPASSO_{cetf}\ ) - \sum_c\sum_o\sum_e\sum_t\ 0.5\ (COUTM_{coet}\ \ SUPASSO_{cetf}\ ) \\
& - \sum_c\sum_o\sum_e\sum_t TRANSACHA\ COUTM_{coet}\ \ SUPLOCA_{coetf} \\
& - \sum_c\sum_o\sum_e\sum_t COUTV_{coet}\ \ SUPAUTO_{coetf} \\
& + \sum_c\sum_o\sum_e\sum_t TRANSVENT\ COUTM_{coet}\ \ SUPLOCO_{coetf}\ - TRANSACHA \\
& \sum_p TRAVSAL_{pf}\ \ SALARIE_p + TRANSVENT + \sum_p TRAVSALV_{pf}\ \ SALARIE_p \\
& + \sum_m TRAVSVENT_{mf}\ \ PRIXPI_m - \sum_m\sum_p TRANSACHA\ ?AHCATALF_{mpf}?PRIXPF_m \\
& - \sum_m\sum_p TRANSACHA\ \ ACHATALI_{mpf}\ \ PRIXPI_m \\
& - \sum_m\sum_p TRANSVENT\ \ VENTALNS_{lpf}\ \ PRIXALINS_l \\
& - \sum_l\sum_p TRANSCHA\ \ ACHATANS_{lpf}\ \ PRIXALINS_l \\
& + \sum_y PBA_y\ \ EFFECTIF_{yf} - \sum_k CHARGEFIX_k\ \ MACHINES_{kf} \\
& - \sum_y\sum_p VET_p\ \ EFFECTIF_{yf} + \sum_m STOCK_{mf} - STOCKI_{mf}\ \ PRIXE_m
\end{aligned}
$$

The objective function is maximized subject to a number of constraints. These constraints, or equations, consist of real constraints and accounting balances either at the farm level or the community level.

The first constraint is related to land availability and takes into account the conversion of the area converted from perennials to cereals and from cereals into perennials.

$$
\begin{aligned}
& + \sum_c\sum_t SUP_{cetf} + \sum_c\sum_t SUPPREA_{cetf} + \sum_c\sum_t SUPASSOD_{cetf}??????? \\
& \leq\ DISPLAND_{ef} + \sum_c\sum_t\sum_a\ \ DEFOP_{cetfa}
\end{aligned}
$$

The area planted in perennials is also constrained by the area converted between cereals and opuntia and the initial land allocated to perennials.

$$
SUPP_{cetfa}\ = \ CROPIPSA_{cfet,a-1}\ - DEFOP_{cetfa}\ + \ SUPPREA_{cetf}?
$$

The next constraint is related to labor allocation and usage. This includes labor needs for both crop and livestock activities.

$$
\begin{aligned}
&+\sum_{t}\sum_{e}\sum_{c} BESTRA_{tp}\ SUP_{cetf} \\
&+\sum_{t}\sum_{e}\sum_{c} BESTRA_{tp}\ SUPLOC_{cetf} \\
&+\sum_{t}\sum_{e}\sum_{c} BESTRA_{tp}\ SUPASSO_{cetf} \\
&+\sum_{t}\sum_{e}\sum_{c}\sum_{a} SUPP_{cetfa}\ BESTROP_{tp} + TRAVEL ? + ? TRAVMA_{pf} \leq TRAVEIU_{pf}
\end{aligned}
$$

Balances for labor use takes into account the use of surplus labor outside the farm and the

$$TRAVALU_{pf} + TRAVSALV_{pf} \leq DISPTR_{f} + TRAVSAL_{pf}$$

possibility to hire labor if deficits from the household endowment appear.

The needs in terms of livestock feeding are met from various sources. The equilibrium for storable feed production and utilization is reached though the following equation. Note that different contractual arrangements in terms of tenure yield a different outcome for storable feed quantity obtained.

$$
\begin{aligned}
&- STOCKI_{mfp} - STOCKI_{mf,p-1} - \sum_{c}\sum_{e}\sum_{t} SUP_{cetf}\ RENDP_{cmet} \\
&- \sum_{c}\sum_{e}\sum_{t} SUPLO_{cetf}\ RENDP_{cmet} - 0.5 \sum_{c}\sum_{e}\sum_{t} SUPASSO_{cetf}\ RENDP_{cmet} \\
&- 0.5 \sum_{c}\sum_{e}\sum_{t} SUPASSO_{cetf}\ RENDP_{cmet} + VENTP_{mf} - ACHATALF_{mpf} - ACHATALI_{mpf} \\
&+ \sum_{y} CONSOM_{mypf} + STOCK_{mfp} \leq 0
\end{aligned}
$$

As a feature of agricultural policy in Algeria, farmers have a limit in terms of access to feed from the official channels.

$$\sum_{p} ACHATALF_{mpf} \leq DOT_{mf}$$

Livestock owners have also access to non-storable feeds from cropping activities. If their own resources are not enough to feed their animals, they have to resort to purchases. On the other hand, surpluses could be sold to other livestock producers. The balance for non-storable feeds is written as:

$$
\begin{aligned}
&-\sum_c\sum_e\sum_t SUP_{cetf}\ CALPRO_{clpet} \\
&-\sum_c\sum_e\sum_t SUPLOC_{cetf}\ CALPRO_{clpet} \\
&-\sum_c\sum_e\sum_t\sum_a SUPP_{cetfa}\ CALPRO_{clpet} + VENTALNS_{ypf}\ ? - ACHATALNS_{ypf} \\
&+\sum_y CONSOMP_{lypf} \leq 0
\end{aligned}
$$

One important specification in this model is the inclusion of physiological constraints related to livestock feeding requirements. The first set of equation covers minimum energy needs, the second set specifies the minimum protein needs while the third set looks at the maximum dry matter intake for small ruminants. The specification is such as the needs are met though three sources (storable feeds, non-storable feeds and intake from rangeland).

Energy needs:

$$
\begin{aligned}
&+ BENERGIE_{yp}\ EFFECTIF_{yf} - \sum_m CONSOMM_{mypf}\ ENM_m \\
&- \sum_l CONSOMP_{lypf}\ ENP_p - \sum_z PRELEV_{zypf}\ UFP_z \leq 0
\end{aligned}
$$

Protein needs:

$$
\begin{aligned}
&+ BMAD_{yp}\ EFFECTIF_{yf} - \sum_m CONSOMM_{mypf}\ MADM_m \\
&- \sum_l CONSOMP_{lypf}\quad MADP_p - \sum_z PRELEV_{zypf}\quad MADPA_z \leq 0
\end{aligned}
$$

Dry matter requirements:

$$
\begin{aligned}
&+ BMAD_{yp}\ EFFECTIF_{yf} - \sum_m CONSOMM_{mypf}\ MADM_m \\
&- \sum_l CONSOMP_{lypf}\ MADP_p - \sum_z PRELEV_{zypf}\ MADPA_z ?? \leq ?? 0
\end{aligned}
$$

Some constraints are also imposed on the composition of the herd. First, there is a minimum male/female ratio to maintain to assure reproduction patterns within the flock.

$$+ EFFECTIF_{bf} - \sum_{s} EFFECTIF_{bf}\ TXREPRO_{sb} \leq 0$$

Culling of animals is also a major feature of livestock flock management. Animals beyond a certain age (usually among ewes and does) have to be sold on the market at a ratio of “tauref”.

$$VENTEAN_{uf} - EFFECTIF_{uf}\ TAUREF_{u} \leq 0$$

Animals within the flock move to a different growth stage within the year. This is represented by a somehow complex set of equations linking different types of animals and taking into consideration mortality and birth patterns. At the same time, sales of animals are limited by the size of the flock available to avoid speculative behavior in the model.

$$+ EFFECTIF_{yf} \leq + \sum_{x}(EFI_{xf} + EFFECTIF_{yf} - VENTEAN_{yf} + ACHATAN_{yf})(1 - TXMOR_{x})$$
$$+ \sum_{b} 0.5\ (EFFECTIF_{bf}\ TAUPRO_{b}\ PARENT_{yb}) + EFI_{yf}\ (1 - TXMOR_{y})$$
$$- VENTEAN_{yf} + \sum_{x} ACHATAN_{xf}\ REMPLACE_{yx}$$

$$VENTEAN_{yf} \leq EFFECTIF_{yf} + EFI_{yf}$$

Mechanization imposes also a set of constraints at the farm and community level. One set of equations controls the use of each type of machinery in each period according to the initial endowment in terms of equipments.

$$+ \sum_{c}\sum_{e}\sum_{t}\sum_{o} SUPAUTO_{coetf}\ DUREM_{otk}\ CALENDR_{op}$$
$$+ \sum_{c}\sum_{e}\sum_{t}\sum_{o} SUPLOCO_{coetf}\ DUREM_{otk}\ CALENDR_{op} ?? \leq CAPACITE_{kfp}$$

Mechanization involves also labor for driving the machines. This is handled through the following equation:

$$+\sum_c\sum_e\sum_t\sum_o\sum_k SUPAUTO_{coetf}\ DUREM_{otk}\ CALENDR_{op}\ DRIVER_k$$
$$+\sum_c\sum_e\sum_t\sum_o\sum_k SUPLOCO_{coetf}\ DUREM_{otk}\ CALENDR_{op}\ DRIVER_k \leq TRAVMA_{pf}$$

One transfer equation equates the sum of machinery needs with the supply from own and rented equipments.

$$-\ SUPAUTO_{coetf} - SUPLOCA_{coetf} + SUP_{coetf} + SUPLOC_{coetf} + SUPASSO_{coetf} \leq 0$$

Risk has been introduced via a Target-MOTAD specification (Tauer, 1983). To reproduce risk behavior in the community, a set of equations has been defined for each state of nature to reproduce endogenously a distribution of observed income and negative deviations with respect to a target revenue.

$$TARGET_f - REVENUO_{fn} + ECART_{fn} \leq 0$$

A constraint limits the sum of these deviations to a risk tolerance parameter specific to each farm type.

$$\sum_n ECART_{fn} - PROBA_n \leq TOLERANCE_f$$

Rangeland use is limited by availability. The next equation captures this constraint.

$$\sum_y\sum_f PRELEV_{zypf} \leq SUPER_z\ PRODU_{zp}$$

The constraints presented above are in fact real constraints because they can restrict the level of total community income; when these constraints are binding, the value of the objective function is lower than the one with no constraints. Several other constraints are included in this system to limit the availability of factors of production such as land, capital and labor at the community level. Supply of all these factors is not unlimited because of various institutional and socio-economic factors. Balance equations, or accounting rows in LP terminology, are included for the sake of calculating variables for easy incorporation in the objective function or in a real constraint equation, and/or for the computation of an aggregate (e.g. cash receipts, expenses, observed revenue, etc…). It should be understood that these equations do not restrict the value of the objective function[1].

The last equation constraints cash availability at the farm level. The extent of expenditures per period is limited by cash income, loans of different terms and from different channels and their repayment schedule and the balance from the previous period (season or year).

$$+FONDR_f + SOLDE_{p-1,f} + RECETTE_{pf} - DEPENSES_{pf}$$
$$- SOLDE_{pf} + \sum_d EMPRUNT_{df} - \sum_d EMPRUNT_{df} (1+TX_d) \geq 0$$

[1] For the ease of presentation and because of their standard economic nature, these equations are not presented in this description of the model. For more information, see the GAMS code program available upon request from the authors.

Table 1: Sets and subsets of indices in the COMPESA Model

Indices	Description	Elements
C	Cultures	
Q[C]	Subset for cereal crops	
O	Technical operations	
E	Soil type	
T	Type of technology used	
K	Type of machinery	
A	Age of perennials plants	
Y	Type of animals	
S[Y]	Subset for Males animals	
B[Y]	Subset for Female animals	
U[Y]	Subset for Adult animals	
X[Y]	Subset for Young animals	
M	Storable feeds	
L	Non-storable feeds	
P	Period	
N	State of nature	
D	Type of Credit	
F & J	Farm type	
Z	Type of rangeland	

Notes: R[V] indicates that R is a subset of V;

Table 2: List of parameters in the model

Parameter name	Description	Units of measurement
AMORT/ AMORTISS	Depreciation of machines	
BENERGIE	Energy needs	UF/period
BESTRA	Labor needs for crops	days
BESTROP	Labor needs for perennials	days
BMAD	Protein needs	Gr/period
BMS	Dry matter limit	kg par periode
CAPACITE	Machine time available	period
CARBURANT	Fuel consumption rate for machinery	hours
CHARGEFIX	Fixed cost for machinery	DA
COUT	Input costs	dinars par ha
COUTM	Cost of mechanical operations	DA
COUTV	Variable costs	DA/ha
CROPIPSA	Observed land allocation	ha
DATEREAL	Date of credit availability	period
DATEREMB	Date of credit repayment	period
DISPLAND	Owned land available	
DISPLANDa	Land in association available	
DISPLANDL	Rented land avaialble	
DISPtr	Labor endowment	Days/year
DOT	Limit on subsidized feed availability	Kg/??
DRIVER	Number of persons for mechanical operations	Person/unit
DUREE	Duration of mechanized operations	Hours/ha
DUREEt	Labor needs for cereal crops	Days/ha
DUREEtrop	Labor needs for perennial crops	Days/ha
DUREM	Duration of machinery utilization	Hours/ha
EFI	Initial flock endowment by farm type	heads
ENm	Net energy from storable feeds	UF/kg
ENp	Net energy from non-storable feeds	UF/kg
ENTRETI	Cost of machinery maintenance	DA/unit
FONDR	Cash available at beginning of campaign	DA
FRAISE	Maintenance cost of perennial crops	DA/ha/year
FRAISI	Installation costs for perennial crops	DA/ha/year
INCITEOP	Subsidy for perennial crop establishment	DA/ha/year
INDREC	Harvest index	%
LAMBDA	Risk aversion coefficient	unitless
MADm	Protein availability for storable feeds	Gr/kg of feed
MADp	Protein availability for non-storable feeds	Gr/kg of feed
MADpa	Quantity of protein per kg of dry matter	G/kg
MB	Gross margins	Da/ha
MBp	NPV of annual cash flows for perennial crops	Da/ha/year
MBPA	Annual gross margins	DA
MSm	Dry matter per kg of storable feed	%
MSp	Dry matter per kg of non-storable feed	%
NIVGRT	Level of guarantees limiting access to credit	DA/household

NUMB	Number of farms by cluster	unitless
PB	Crop gross product	Da/ha
PBA	Gross product per animal type	Da/head
PBp	Gross product for perennial crops	Da/ha
PRIX	Crop output prices	Da/quintal
PRIXALINS	Non-storable feed prices (standardized from ha to quintals)	Da/quintal
PRIXan	Livestock prices	Da/head
PRIXloc	Land rental prices	Da/ha
PRIXm	Price of mechanized tasks	Da/hour
PRIXmec	Purchase price of new machinery	Da/unit
PRIXp	Price of perennial crops	Da/quintal
PRIXPF	Price of storable feed for subsidized feed (government channels)	Da/quintal
PROBA	Probability of occurrence of each state of nature	%
PRODU	Production calendar for the rangeland	Kg of dry matter/HA
QUANTINTR	Quantity of inputs	unit
r	Discount rate	
REND	Grain yield	Quintal/ha
RENDP	By-product yield	Quintal/ha
RENDPAGE	Fruit yield for cactus pear by age	Quintal/ha
RENDpe	Fruit yield for cactus pear by marketed ha	Quintal/ha
SALAIRE	Wage rate	Da/day
STOCKI	Initial feed stocks	quintal
SUPER	Area of rangeland	ha
TARGET	Target revenue	Da/household
TAUpro	Prolificity rate	Lamb/ewe
TAUREF	Culling rates	%
TOLERANCE	Average Negative deviation from target revenue allowed	%
TOTREV	Total revenue for the community	
TRANSACHA	Transaction costs for purchases	unitless
TRANSVENT	Transaction costs for sales	unitless
TRAVEL	Number of days needed for machinery handling	Man-days/period
TX	Interest rate	
TXMOR	Mortality rate for livestock	
TXREPRO	Number of reproductive rams	Rams/100 ewes
UFP	UF per kg of dry matter for non-storable feed	UF/kg
VET	Veterinary costs	Da/head

Table 3: List of Variables in the Model

Variables	Description	Unit of measurement
$REVENU_{f}$	Average revenue	DA/year
$REVENUo_{f,n}$	Expected revenue by state of nature	DA/year
REVENUTT	Total community revenue	DA/year
$SUP_{c,e,t,f}$	Area owned allocated to crops	Ha
$SUPLOC_{c,e,t,f}$	Area rented-in	Ha
$SUPASSO_{c,e,t,f}$	Area taken in association	Ha
$SUPASSOD_{c,e,t,f}$	Area given in association	Ha
$SUPPREA_{c,e,t,f}$	New area planted in perennial crops	Ha
$DEFOP_{c,e,t,f,a}$	Area withdrawn from perennial crops	Ha
$SUPASSOX_{c,e,t,f,j}$	Area taken in association by pair	Ha
$SUPASSODX_{c,e,t,f,j}$	Area given in association by pair	Ha
$TRAVSAL_{p,f}$	Labor hired in	Hours/period
$TRAVSALV_{p,f}$	Labor hired out	Hours/period
$TRAVAIU_{p,f}$	Total labor used	Hours/period
$STOCK_{m,f,p}$	Storable feed stocks at end of period	Kg
$SOLDE_{p,f}$	Cash balance at end of period	DA
$RECETTE_{p,f}$	Cash receipts for the period	DA
$DEPENSES_{p,f}$	Cash expenses for the period	DA
$VENTALNS_{l,p,f}$	Sales of non-storable feeds	Ha
$ACHATALNS_{l,p,f}$	Purchases of non-storable feeds	Ha
$VENTP_{m,f}$	Sales of storable feeds	Kg
$ACHATALF_{m,p,f}$	Purchases of storable feeds from the public channels	Kg
$ACHATALI_{m,p,f}$	Purchases of storable feeds from the market	Kg
$SUPP_{c,e,t,f,a}$	Area planted in perennial crops	ha
$EMPRUNT_{r,f}$	Loans by type	DA
$VENTEAN_{y,f}$	Sales of animals by head and type	head
$ACHATAN_{y,f}$	Purchases of animals by head and type	head
$EFFECTIF_{y,f}$	Herd composition for each period	head
$CONSOMm_{m,y,p,f}$	Consumption of storable feeds	kg
$CONSOMp_{m,y,p,f}$	Consumption of non-storable feeds	kg
$PRELEV_{z,y,p,f}$	Intake form rangeland	Kg
$SUPAUTO_{c,o,e,t,f}$	Area covered by own mechanical equipment	ha
$SUPLOCA_{c,o,e,t,f}$	Area covered by mechanical equipment rented in	ha
$SUPLOCO_{c,o,e,t,f}$	Area covered by own mechanical rented out	ha
$TRAVMA_{p,f}$	Labor used for mechanical equipment	Hours/period
$ECART_{f,n}$	Deviations from target revenue for each state of nature	%

CHAPTER THREE

FALHA COMMUNITY MODEL FOR POLICY, INSTITUTIONAL AND TECHNOLOGY SIMULATION (FCOMPITS)

The quadratic programming model FCOMPITS of the Falha (Jordan) community consists of several groups of constraints or equations. In this chapter, a complete specification is given. The symbols used are defined in three tables following the equations: indices in Table 1, variables in Table 2 and coefficients in Table 3. The model is multi-periodic (four seasons) and dynamic within the year. It is static in nature in the sense that the optimization process is done over a 1-year planning horizon and looks at short to medium term type of adjustments. Its non-linearity comes from the Mean-Variance type of specification in the objective function described next.

The model objective function for the Falha community level maximizes the weighted average of a certainty equivalent function for each farm type where α and CE are respectively the weight and the certainty equivalent function of each farm type in the community population.

$$Max\ Z = \sum_{y} \alpha_y CE_y$$

The activities chosen by crop-livestock integrated farms draw upon the limited resources of land, labor and feed. The set of optimal activities includes decisions about crop choices, crop rotations and labor use, and livestock feeding combinations, and marketing of sheep and goat live animals and associated by-products. The certainty equivalent function for each farm type of the form [E(R) – 0.5 λV(R)] is defined as:

$$
\begin{aligned}
CE_y = ?\sum_{r} & AREAR_{yr}\ PROFITE_r \\
& + \sum_{s} AREAT_{ys}\ PROFITET_s + \sum_{a} NUMBER_{ya}\ GPL_a - \sum_{d} AREA_d\ PLAND_d \\
& - \sum_{e} HIRED_{ye}\ SALAR_e - \sum_{a}\sum_{f}\sum_{e} CONS_{yafe}\ PRICEF_f - \sum_{l} CREDIT_{yl}\ INT_l \\
& - 0.5\ LAMBDA_y\ (\sum_{r}\sum_{o} AREAR_{yr}\ AREAR_{yo}\ Q_{ro} + \sum_{a}\sum_{j} NUMBER_{ya}\ NUMBER_{yj}\ QQ_{aj} \\
& + \sum_{a}\sum_{r} NUMBER_{ya}\ AREAR_{yr}\ QQQ_{ar})
\end{aligned}
$$

The objective function at the farm level states that producers maximize the expected return to crop (AREAR), tree (AREAT) and animal (NUMBER) activities with a penalty related to the variability of returns for these activities minus various costs related to hired labor (HIRED), consumption of feed (CONS), land rental (AREA), and cost of formal and informal credits (CREDIT). The last term in parenthesis represent the variance of the portfolio where Q is the variance-covariance matrix for crop activities, QQ the matrix for livestock activities and QQQ the covariance between crops and livestock.

This maximization occurs under resource availability constraints for land to be allocated between various crops and trees.

$$\sum_{r} AREAR_{yr} + \sum_{s} AREAT_{ys} \leq TOTAREA_{y}$$

The equilibrium for supply from own labor (WORKS) and hired labor (HIRED) and demand for labor for livestock, crops and trees on a seasonal basis is reached through the following equation.

$$LABNEEDL_{e} + \sum_{r} LANBNEEDC_{re}\, AREAR_{yr} + \sum_{s} LABNEEDT_{se}\, AREAT_{ys} - WORKS_{e}? - HIRED_{ye} \leq 0$$

A constraint on cash availability limits the level of feed purchases, type of crop technology to be used, hired labor and purchases of young animals for fattening purposes.

$$\sum_{l} CREDIT_{yl} + CASH_{y} \geq CONSUM_{y} + \sum_{c} \sum_{r} AREAR_{yr}\, COST_{cr} + \sum_{e} HIRE_{ye}\, SALAR_{e} + \sum_{a} BUYLIV_{ya}\, PRICEL_{a}$$

Access to credit in thee region tends to be limited by the size of the area available via an institutional limit (LIMIT).

$$CREDIT_{yl} \leq LIMIT_{l}\ TOTAREA_{y}$$

The next three equations are the standard dry matter limit, and protein and energy needs by type of animal and season for livestock feeding specification.

$$DMNEEDS_{ae}\ NUMBER_{ya} - \sum_{f} CONS_{yafe}\ DMCOMP_{f} - \sum_{c} INTAKE_{ycae} \leq 0$$

$$CPNEEDS_{ae} NUMBER_{ya} - \sum_{f} CONS_{yafe} CPCOMP_{f} DMCOMP_{f} - \sum_{c} INTAKE_{ycae} CPGRAZ_{c} \leq 0$$

$$MENEEDS_{ae}\ NUMBER_{ya} - \sum_{f} CONS_{yafe} MECOMP_{f} DMCOMP_{f} - \sum_{c} INTAKE_{ycae} MEGRAZ_{c} \leq 0$$

Total feed intake from own land is limited by area available for cropping.

$$\sum_{a} INTAKE_{ycae} \leq DMGRAZ_{ce}\ AREAC_{yc}$$

The last equation links the initial flock size with the purchases of fattening animals and the current flock size.

$$-NUMBERI_{ya} - BUYLIV_{ya} + NUMBER_{ya} \leq 0$$

Table 1: Sets and subsets of indices in the FCOMPITS Model

Indices	Description	Elements
c	Crops	Barley, Wheat
s	Trees	Almonds, Olives, Grape
r & o	Type of rotation for crops	Barley-Barley, Barley-Fallow, Wheat-Fallow
f	Type of feed	Grain, straw and bran
a & j	Type of animals	Sheep and Goat
e	Season	Autumn, Winter, Spring and Summer
l	Type of Credit	Formal and Informal
y	Farm type	Small, Medium 1, Medium 2 and Large
d	Type of land tenure	Meeri and Mulk

Table 2: List of Variables in the Model

Variables	Description	Unit of measurement
Z	Total certainty equivalent for the community	JD/year
CE_y	Certainty equivalent by farm type	JD/year
$AREAT_{y,s}$	Area planted in trees	Du
$AREAR_{y,r}$	Area planted for each rotation	Du
$AREAC_{y,c}$	Area planted for each crop	Du
$HIRED_{y,e}$	Hired labor used	Hours/season
$CREDIT_{y,l}$	Amount of loan obtained from bank or informal sector	JD
$CONS_{y,a,f,e}$	Feed consumption by type of animal and by season	Kg/head
$NUMBER_{y,a}$	Number of animal of a given type	Head
$BUYLIV_{y,a}$	Animals bought to increase the herd size	Head
$INTAKE_{y,c,a,e}$	Intake from grazing on biomass remaining on the field	Kg

Table 3: List of parameters in the model

Parameter name	Description	Units of measurement
ALPHA	Number of farms in each class	
AREA	Total area available for each farm type (owned)	du
CASH	Starting wealth for the household	JD
CONSUM	Household consumption	JD
COST	Contribution of each crop in total cost	per du of rotation
COSTT	Total input cost for tree production in	JD/du
CPCOMP	Protein content	kg / kg of feed
CPGRAZ	Protein content in dry matter grazed	%
CPNEED	Crude protein per animal	Kg/day
CPNEEDS	Crude protein per animal per season	Kg/season
CROPROT	Mapping of crops in rotation	N/a
DAYS	Number of days per season	days
DMCOMP	Dry matter per kg of feed	Kg/kg of feed
DMGRAZ	Dry matter produced by crop by season to be grazed	Kg/du
DMNEED	Dry matter needs per animal	Kg/day/head
DMNEEDS	Dry matter per season per animal	Kg/season/head
GMC	Contribution of each crop into green matter of rotation	JD/du
GMCT	Total revenue from tree production	JD/du
GMM	Profit made on equipment sales	JD/unit
GPL	Gross product by zoo-technical	JD/head/year
INSTREE	Parameter on tree constraint	N/a
INT	Annual interest rate by loan origin	%
LABNEEDC	Labor needs for rotation	man-day/season
LABNEEDL	Labor needs for livestock production	man-day/season
LABNEEDT	Labor needs for trees in man-day per season	man-day/season
LAMBDA	Risk aversion coefficient	
LIMIT	Limit on credit available	JD/du
MAINT	Maintenance cost by type of equipment	JD/unit
MECOMP	Metabolic energy in feed	KJ/ kg of dry matter feed
MEGRAZ	Metabolic energy in dry matter grazed	KJ/ kg of dry matter feed
MENEED	Metabolic energy in feed per animal	MJ/Kg/day/season
MENEEDS	Metabolic energy needs per season per animal	MJ/Kg/season
NUMBERI	Initial number of animal zoo-technical unit	ZU
OUWORK	Working days for off farm activities	Days/month
PERFORM	Physical production by zoo-technical unit	Kg/ZU
PERSA	Number of persons in the family working on the farm	N/a
PF	Fruit price	JD/kg
PG	Grain price	JD/Kg
PLAND	Land price (annual rent) by type	JD/year

PRICE	Input cost for crop production	JD/unit
PRICEF	Feed price	JD/kg
PRICEL	Initial investment to increase herd by one ZU	JD/unit
PRICEO	Price of livestock output	JD/unit
PRICET	Input cost	JD/du
PROFITE	Profit for one dunum of rotation	JD/du
PROFITET	Total profit from tree production per dunum	JD/du
PS	Straw price	in JD per Kg
Q	Covariance matrix for crop activities	N/a
QQ	Covariance matrix for animal activities	N/a
QQQ	Covariance matrix between animal and crop activities	N/a
QUANTITY	Units of inputs per dunum planted by crop	Unit/du
QUANTITYT	Inputs needed for each dunum planted with trees	Unit/du
SALAR	Wage rate	JD/day
TOTAREA	Total area initially available for each farm type	du
WORK	Available labor by month for on and off-farm activities	Man-days
WORKS	Available labor by season in days	Man-days/season
YF	Fruit yield	Kg/du
YG	Grain yield for each crop in the rotation	Kg/du
YS	Straw yield for each crop in the rotation	Kg/du

CHAPTER FOUR

SYNTHESIS OF THE EFFECTS OF AGRICULTURAL POLICY REFORM: A CROSS COUNTRY COMPARISON AT THE COMMUNITY LEVEL

INTRODUCTION

The initial policy reforms in a number of WANA countries have led to some reductions in the level of support, but with wide variations among countries and commodities depending on the context in which agricultural adjustment has been undertaken. None of the WANA countries have undertaken comprehensive reform leading to lower levels of support to the agricultural sector, reduced input market distortions caused by subsidization policies, although several countries have in recent years engaged in substantial reforms involving some agricultural commodities, inputs and substantially decreased budgetary expenditures for the sector. It is in this context of transitional mode of government intervention that the current research has made an attempt to look at how reduction in market price support and input subsidies could affect the future of crop and livestock production in the low rainfall areas.

The synthesis study begins by describing the major agricultural policy reforms simulated for the cross-country comparisons of the effect of structural adjustment in agriculture. It then examines the effects on production, land use, farming practices and input use in the crop and livestock sectors that could occur as a result of these reforms. This is followed by a discussion of the impacts of these changes on selected socio-economic indicators related to income and its distribution. Issues related to the impact on the environment are addressed in the next section. A general evaluation of the impact of policy reforms is undertaken in the last section. This chapter concludes with a summary of the cross-country comparisons and the policy implications of this kind of research.

It is important to note that while agricultural policies of the type analyzed in this synthesis are determined at the national level, the income growth, equity and environmental effects of policy reforms will vary because of the spatial diversity of physical resource characteristics and socio-economic conditions within countries but also across countries. Thus, the discussion in this chapter assumes that that we are dealing with a community representing, at the national level, the different systems and conditions found in low rainfall environments with a recognition that more work is required to reflect local, regional and national diversity within and across WANA countries.

The level of aggregation of data and the concept of community representativity are also directly related to the extent to which results of the model baseline and simulations can be compared across the WANA region. For most financial, production and environmental indicators presented in this study, differing local conditions mean contrasting income, equity and resource condition impacts across communities and consequently countries requires careful interpretation, especially in comparing the absolute levels for each indicator whether expressed in financial or physical terms. One appropriate comparison, followed throughout this synthesis, however, was to compare the trends or changes in indicators using the baseline level as a benchmark and indices whenever appropriate. Developments on the economic, environmental and social fronts are also provided through indicators combining information from more than one of the three different dimensions.

The agricultural price policy reforms simulated in this study cover both product prices and input prices. To get a clear understanding of the adjustment implications, enough disaggregation in the type of output and input prices (by product and channel used) is allowed by the two models. For example, the Algerian community model distinguishes between feed bought from the public channel and subjected to quantitative restrictions and feed directly purchased from the free market. A review of various agricultural structural adjustment programs in both Algeria and Jordan show a number of similar targets sought for in the reform process. These targets include:

a. eliminating all controls over margins and schemes equating prices at the regional level;
b. confining price interventions to a basic minimum of commodities;
c. reducing distortions affecting efficiency of input use, with interventions in markets to be restricted to output prices; and
d. targeting any subsidy scheme for social reasons via non-distortionary means.

This study of the impact of policy reforms on these two low rainfall area communities aims to identify options, priorities, measures and levels of intervention to mitigate the potential adverse effects on some categories of households and producers and strengthen the positive consequences on the corners of the critical triangle. The practical design and sequencing of agricultural price policy reform needs to be developed based on a thorough exploration of various combinations of pricing reforms. It is to address this need in terms of preparatory work that we have chosen to look first at some typical scenarios of interest to policy makers not only in Algeria and Jordan but also in other countries of the region facing the same type of challenges when it comes to rural development. In this synthesis evaluation, the focus will be on some sub-sectoral issues related to input subsidization and output support for the most critical sectors in dryland agriculture, namely the cereals and the livestock sub-sectors. Table 1 shows the various combinations of pricing policy changes evaluated for the two communities.

A. RESULTS FOR THE FALHA COMMUNITY

1. EFFECTS ON PRODUCTION, FARMING PRACTICES AND INPUT USE

The effects of reform depend on the way pricing policies and policy change influence farmers' decisions: through, for instance, the total cultivated land area, changes in the crop or livestock composition, shifts in agricultural practices, and feed strategies. The kind of policies investigated in this study impact on several of these factors simultaneously. We will explore next how input pricing policy changes and market price support changes affect indicators related to agricultural production when conducted separately (S1 and S2) as well as simultaneously (S3).

Changes in land use

Reduction in market price support for crops and livestock as well as feed subsidies has an effect on land usage. We tend to notice some similarities in the land use pattern changes as more land goes into wheat production because of lower prospects to meet minimal needs for family consumption by buying foodgrains from the market[1]. At the same time, in response to higher feed prices, farmers have to increase land allocated to barley to meet the feed needs of their animals. This increase is due to the large farmers in Falha having to produce their own feed rather than renting their lands to outside farmers from other communities.

Changes in the volume, and composition of output

Input pricing reform with the reduction of feed subsidies to the livestock sector is transmitted also to the crop sector, as some important cropping pattern changes have to be made to feed animals along changes in the level of output and its composition. With reductions in crop and livestock producer prices and input subsidies, livestock production is expected to decline substantially (sheep production goes down by 1/3 in Falha) while crop production tends to increase (+34% for barley).

The composition of crop and livestock output changes as a result of changes in the relative profitability of a commodity compared to other commodities within the same group (say in terms of substitution between grains or type of animals) and across groups (substitution between crops and livestock). Such shifts in commodity composition occur in the case of general support reductions because support levels differ across commodities prior to pricing policy reform. In WANA, livestock tends to be more highly protected than livestock. As a result, the changes are more substantial in the livestock sector than in the crop sector and differ quantitative and qualitative terms depending on the type of support reduced (market output price or input subsidies). Reductions in feed subsidies push farmers tend to sell goats (-38%) to maintain sheep at constant levels. When reforms are applied to market price support, a different trend emerges. There is a decline in sheep production (-4%) and goat numbers go down by 20%.

The trends in terms of output levels and flock composition when market price support and input subsidies are reduced suggests that a large proportion of the flock has

[1] Reduction in income explains the lower reliance on wheat bought from the market. The impact of policy reform on income will be discussed later.

to disappear if farmers do not undertake a substantial overhaul of their feeding management strategies and increase the productivity of their animals.

2. SOCIO-ECONOMIC EFFECTS AND ECONOMIC INDICATORS

After having reviewing the most important changes in terms of production (quantity and composition), we turn to an analysis of the financial implications of pricing policy reforms. The effects of reduced feed subsidies and lower output prices confirm that reduced support has a substantial negative impact on farm revenues. Whether the changes on the input and output pricing are conducted separately or simultaneously has a bearing not on the direction of the change but more on its magnitude. As the changes affect the major production activities in the low rainfall areas (sheep and barley), the impact is quite heavy for farmers in the community selected regardless of their initial level of wealth though the magnitude of the loss differs across farm types.

Reduction in income levels

Figure 1 shows the simulated impact of input pricing reforms as well reduced output price support on income for the whole community. We chose an index representing the average income in the community with a value of 100 for the base-run (pre-reform situation). The figure shows how vulnerable crop and livestock producers are in Falha and how dependent they are on input and output support. The important changes in terms of income loss arising for the Falha community are expected given the importance played by input subsidies and output support in the livestock production system in Jordan. There seems to be limited diversity and input substitution potential for crops and livestock in even though production of olives tend to provide additional opportunities in Falha.

Effects of reduced agricultural support on income distribution

Concerns about the effect of reduced government support on income distribution have risen as structural adjustment programs have started to be implemented in various countries of the WANA region. The "risk" of political upheaval has often been advanced as a justification to keep the status quo when it comes to agricultural reforms. While those fears could be justified, there have been limited scientific evidence to show the not only the magnitude of losses in income as a result of pricing reforms but also the distributional impacts of those changes and the subsequent equity implications. We outline in this section the most salient findings related to the distribution of support among farms of different sizes and types and across the two communities compared in this synthesis. Assessing the equity implications of output support reform or removal of feed subsidies requires an incidence analysis to indicate which farm types or groups lose or gain by the support removal once it has changed the relative prices, production volumes and incomes in the entire community. It results in estimates of changes in income distribution based on the Gini Coefficient derived from the Lorenz Curve.

The equitability of agricultural support in terms of feed subsidies and market price support for the crops and livestock products produced in low rainfall environment has not been adequately addressed by researchers in the region. As rightly put by Pratt, Le Gall and de Haan, (1997):

> *"...Little quantitative information is available on the equity aspects of subsidized feed distribution systems because the topic is politically sensitive and there is not much experience on which to base the targeting of inputs to less well-off herders..."*

It is this particular issue that we address in this section based on simulation results for the community sites covered in this synthesis.

The original beneficiaries of output support and feed subsidization are likely to lose at least in the short term as reported earlier. This inevitably has implications for the internal income distribution within the two communities. Who loses the most and who loses the least will depend not only on the magnitude of the support but also on the critical nature of its timing. Table 2.1 reports the impact on income distribution for the various policy reforms simulated. The general trend is towards more inequality. The equity imbalances appear partly as a result of the large livestock owners acquiring the highest share of subsidized feedstuffs as to be discussed in more details in Table 2.2. A lower support on the output side reduces equity as large and rich farmers tend to adjust more effectively to the new environment and are able to maintain an adequate level of income as opposed to the small and poor farmers being hit harder in those circumstances. Overall, a policy reform combining reduced feed subsidies and lower output support leads to a worsened income distribution.

Comparing the distribution of support with that of the initial level of productive resources and income yield interesting insights into how agricultural pricing policies in Jordan performs with regard to the operational criteria of equity and targeting in low rainfall areas. The analysis for the community in Jordan shows that the distribution of support is close to the distribution of livestock output (in terms of sheep numbers), with the largest, and hence the richer farmers, being the main beneficiaries (see Table 2.2) of the feed subsidy program. In this sense, support is not equitable when 30% of the community population is enjoying more than 50% of the total feed support. The removal of output support tends to increase income disparities between farm types (moving from a baseline of .31 to .44 with the more drastic scenario of input and output support reduction). In summary, support to farmers in Jordan tends to maintain the original disparities between large and small flock owners since the support is more output related than targeted to specific segments of the population. This condition could provide a justification for the Jordanian policy-makers to review the criteria of equity in agricultural support and pay a closer attention to targeting considerations.

Could the fact that support as a whole is relatively concentrated on the more endowed farmers reflects an implicit Jordanian policy objective to promote livestock production based on large flock ownership and consequently large landholdings, as it is the case for some developed and developing countries? Small and landless flock owners receive only 5% of the total feed subsidies although they are more dependent on support than large ones given their limited access to land to generate the necessary feed resources (including from grains, crop grazing and rangeland). In order to influence the overall distribution of support, a system where payments are targeted to smaller farms, should be put in place.

Potential entry and exit patterns in crop and livestock production

Changing the incentive structure in the livestock pricing systems in low rainfall environments raises some concerns about who will stay in the business of livestock rearing and who will be unable to assure productivity levels and feeding patterns that could yield profitable levels of returns. Removing feed subsidies calls for some substantial reshuffling in terms of feeding strategies and herd composition.

This issue of exit from the livestock business raises questions regarding the potential of farmers in the LRA to adjust to less distorted markets by modifying their current production system. How do farmers react in terms of handling their entire production operations? We have seen earlier some substantial herd size and composition modifications and subsequent changes in feeding patterns. The cropping operations tend also adjust to the new incentive structure. These changes are being reflected in the variation of the non-subsidized portion of their income once feed subsidies are taken into account in the computation of their total income. Figure 2 shows that Falha farmers have a very limited potential to increase substantially the non-subsidized portion of their income. This indicates that the feed support system has a very limited multiplier effect, as farmers are not able to substantially transform the feed support in a higher value added and acts as a mere transfer system with limited potential to generate improvements in terms of productivity.

3. EFFECTS ON THE ENVIRONMENT IN RELATION TO CONTEXT SPECIFIC FACTORS

The type of causality linking agricultural pricing policy to the environment explored in the context of dryland agriculture flows from the impact of changes in output an input support on crop and livestock farming practices and activities (for example livestock feeding and land allocation between alternative crops). These practices and activities then translate into specific pressure patterns on the condition of croplands and rangelands. However, it should be understood that some of the changes in production, land use and farming practices resulting from reform might have a deeper impact on the environment than others. Here, the diversity in the site specific agro-ecological characteristics dictates what constitutes a ''substantial'' change as the impact of reform will depend on the production pattern in the two communities studied and the farming systems used, but also on the elements of the environment that are face a greater threat.

In trying to assess these environmental effects resulting from pricing policy reform, two analytical issues pose problems and merit careful consideration. First, how do we link the overall impact at the community level with the specific impacts obtained at the farm level and depending on the production system and socio-economic characteristics of each farm group. This issue is related to the desire to provide general and systematic conclusions about the effect on the environment while recognizing the farm level differences in terms of impact. Second, how do we summarize and weight up trends in the environmental effects when they move in opposite directions? The next discussion attempts to shed light on these issues.

Effects on soils in marginal lands

When pricing policy reform results in less crop production, it is typically the least productive and suitable land that tends to be withdrawn. When these marginal lands are environmentally fragile, their conversion to trees or grazing land (called *"bour"* in the WANA region) has the potential to reduce land erosion. Shifts from crop production (wheat and barley) to grazing or forage production can also improve soil quality. In the WANA region, structural adjustment programs in agricultural is expected to reduce livestock densities and grazing pressure on rangelands, with substantial beneficial effects for land resources. There are, however, some situations, where the withdrawal of land previously allocated to grains, without appropriate soil conservation measures could lead to worsened soil conditions. In this case, there seems to be evidence that policy reforms could lead to positive environmental effects as shown by the proxy indicator[2] used to capture changes in resource condition in this community.

In Falha, trees are an alternative land usage in the medium and long-term. Over the years, farmers have recognized the benefits they could derive from investment in trees and in particular olive and almonds trees. Though further expansion is related to institutional features and financial considerations of a longer-term nature, simulations show that reduced support to crop and livestock could lead to the conversion of land previously allocated to wheat and barley into fruit trees whether the reform comes at the output support level or the input subsidization level and whether it is directed at the crop or livestock sector.

Though it is difficult to determine environmental effects at the community level unambiguously, we can draw some general conclusions on the resource condition impacts of pricing policy reform in Falha. First, there seems to be limited evidence to link resource degradation with poverty. The poor and small farmers do not necessarily react to changes in the policy environment by increasing their pressure on the resource despite their reduced income level as a result of lower support. To this extent, poverty does not appear to contribute to the degradation of natural resources. This confirms that the possible link from poverty to resource degradation is not so well supported by empirical evidence as the link from resource degradation to poverty.

B. RESULTS FOR THE SIDI FREJ COMMUNITY

The Sidi Frej community has important similarities and differences with the Falha community. Though the major ecological features in terms of rainfall, temperature, soil type are similar, socio-economic characteristics and elements in the production system tend to differ. The same type of emphasis will be made for the simulations in terms of

[2] It should be noted that the indicator used (shadow prices trees) is a first approximation of potential environmental pressure; more research would be needed to give a better description of the actual pressure on rangelands and marginal lands for the type of ecology studied.

result presentation. Table 4 shows major average farm indicators for production and financial indicators.

1. EFFECTS ON PRODUCTION AND FARMING PRACTICES

By lowering price support and input subsidies, changes in land use and composition of activities appear. The most important change in trends is relative to the conversion of opuntia (prickly pear), a perennial crop providing fruits for market sales and pads for animal feeding, by cereal crops (mostly durum wheat and barley). The reduction in input subsidies tends to yield relatively smaller changes than those obtained with reductions in output support (2.1% versus 6.3% for the cereal area and -1.2% versus –6.4% for animal sales). Because of the higher costs for livestock feeding and reduction in gross margins, farmers in Sidi Frej tend to keep feeds produced on their farm and rely less on the market. Farmers used to adjust their surpluses and deficits in feed by interacting with the market. This pattern seems to be less pronounced with reduced price distortions on the input or output side.

2. SOCIO-ECONOMIC EFFECTS AND ECONOMIC INDICATORS

The policy reforms simulated in this study involve a progressive and simultaneous reduction of agricultural input and output support and a shift away from measures linked to production or to factors of production. As mentioned earlier, it is likely that in economies where the agriculture sector is protected, market liberalization leads to negative outcomes in terms of income. Indeed, the removal of input subsidies and more importantly the reduction in output support worsens the condition of the average farmer in Sidi Frej. It is the reduction in output support that could hit farmers the hardest with a reduction in income of more than 20%. Reducing distortions on the input side reduces the average income by less than 3%.

The equitability of agricultural support in terms of feed subsidies and market price support for crop and livestock products in Sidi Frej contrasts with the situation prevailing in the Jordanian community of Falha. While a policy reform combining reduced feed subsidies and lower output support leads to a worsened income distribution in Falha, an improvement in equity is noticed in Sidi Frej with a Gini coefficient moving from 0.23 to 0.15. It is the reduction in output support that yields the higher changes in terms of income distribution (0.20 versus 0.22 with lower input subsidies). This could indicate that there is a limited need to design complementary targeted subsidization schemes in Algeria low rainfall areas. It is a broad complementary policy to improve income prospects for all segments of the population that seems to be required in order to improve the welfare of this type of communities.

3. EFFECTS ON THE ENVIRONMENT

While a potential improvement in the environment was detected in Falha based on the shadow price for trees as a proxy for a resource improvement index, pricing policy reforms could lead to land resource degradation in Sidi Frej. The reduction of the area devoted to the perennial crop and the increase in cereals is not a promising factor according to agronomical benchmarks. While efforts have been put in place over the past 10 years to grow opuntia on environmentally sensitive areas, they could be annihilated by the type of policy reforms suggested in the context of agricultural structural adjustment. Despite of the relevance and adequacy of these pricing reforms, additional measures should be put in place to mitigate the negative environmental outcomes and reinforce the positive impact on the nearby rangelands as evidenced by the lower intake patterns for the three scenarios (from –4.6% to –29.1%).

C. MEDIUM AND LONG-TERM IMPLICATIONS OF POLICY REFORMS IN THE LOW RAINFALL AREAS

Agricultural policy reforms have important implications on sustainable development taken in its broader sense as encompassing the economy, the environment and human and social concerns. Measuring the impact of these reforms require the use of a set of commonly accepted indicators reflecting each side of the notion of sustainable development. While, it is difficult to examine a large set of indicators to be able to address concerns expressed by various schools, we have tried in this synthesis analysis to identify some key indicators that could be used by policymakers to assess trade-offs between different dimensions of sustainable development but also help set priorities across different policy interventions. The approach in terms of impact focus relies on different frameworks developed by different international organizations including but not limited to OECD, FAO, and the World Bank. We have therefore chosen to look at how changes in output support and input subsidies simultaneously affect efficiency by looking at the income effect, the importance of government transfers to various farm groups and employment implications. These specific income effects were linked to equity considerations by looking at income distribution within the community and the relative losers and winners from support removal. In particular, we have not only explicated the share of the poor population in total income, but also its share in the total support received. These two dimensions were then linked to the environment by examining at the potential implications in terms of resource use for the croplands and rangelands. Though the analysis for the last dimension was based on a limited number of indicators related to a different ecology (croplands v. rangelands), the analysis has nevertheless identified some important changes in how farmers deal with their environment with a different incentive structure for the commodities produced and the inputs used in the production process.

A new reality in low rainfall areas…

Though many of the environmental problems in WANA low rainfall areas have been caused by a combination of missing markets and policy failure (Pinstrup Andersen, Hazell and Oram, 1997), it is the assistance to crop and livestock production that has the most distorted production and consumption incentives. In doing so, support in agriculture has reinforced more the negative than the positive environmental effects of agriculture. The overall level of assistance to the sector, the relative level of support across crop and livestock commodities, are factors that have influenced not only land use, farming practices and the number of animals kept but also and their impacts on the resource condition. Simulations of the reform of agricultural policies and its associated impact on two dryland communities show that the process should improve the allocation of resources and reduce incentives to misuse rangelands and marginal lands in this type of agro-ecology. Hence, by substantially reducing livestock numbers and feed use (due to a combination of lower output prices and changes in relative input prices), the agricultural pricing reforms would tend to reverse the negative environmental impacts associated with crop, livestock and feed specific policy measures. But in those specific cases where agricultural policies have lead to the maintaining of farming practices that provide environmental benefits (such as the use of perennial crops on environmentally sensitive areas), policy reform could reduce environmental performance, as it was the case for the Sidi Frej community.

…with new opportunities in a context of reduced agricultural support…

Though reductions in price support could initially increase land allocated to grains for animal feeding purposes as part of a short-term adjustment strategy, policy reform is likely to lead to a de-intensification of crop production in the least productive areas. Some land could be shifted into fruit production (for example olives and almonds as simulated in the case of Falha), which is more adapted to the potential of marginal lands but requires a initial investment that farmers lack the capacity to set aside with the current agricultural policy setting and the short-term loss in income. At the same time, if reform is to result in smaller animal herds and lower livestock densities, thereby reducing grazing pressure, increases in animal productivity could be reached as farmers get rid of the least productive elements in their herds. It is in fact this change in the feeding costs and the relative output prices that could lead farmers to rely more on feed produced at the farm level, integrating thereby their cropping and livestock activities in a more integrated way as noticed for the Sidi Frej community.

But serious threats remain…

A move towards reduced market distortions can also have undesirable side effects if it pushes households that have solely relied on crop and livestock production away from agricultural activities. In the communities studied, support has allowed farmers to maintain farming systems that have generated the bulk of their income. Such production systems, face their biggest challenge in the current context of tightened agricultural budgets.

A closer examination at the beneficiaries of price support in the the Jordanian community has shown that while the richer farmers tend to benefit the most from the output support and feed subsidies, it is the small and poor farmers that lose the most from the policy reform process. This is due to the fact that this type of support is generally proportional to the volume of output or input as it is the case for feed subsidies and it tends to disproportionally benefit farmers on large-size farms or with large herds, rather than landless farmers or those on small-size farms, whom policies are supposed to benefit. There are concerns then that equity not only in the level of income but also in the level of support might be reduced if reform causes the least endowed segment of rural populations in low rainfall environments to suffer more than those who can get by without support as evidenced by the impact of reforms on the large farmers in Falha. While the negative impact of this type of adjustment measures is expected in economies protecting the agricultural sector, its magnitude for the small farmers calls for a serious examination of the alternatives that could be put in place to help them.

SUMMARY AND CONCLUDING REMARKS

This synthesis of results obtained with a bio-economic model built for two LRA communities examined the income growth, equity and resource condition impacts of agricultural policy reforms at the output and input level to be carried in Algeria and Jordan. It emphasized the potential effects in terms of land use, crop and livestock production, income levels and its distribution, and environmental sustainability. The results are obtained based on a what-if type of analysis by looking ex-ante on how farmers might respond to changes in the pricing environment. This analysis while showing some important common trends reflects nevertheless the diversity of the local production system and socio-economic context. This study of problems and opportunities in two representative low rainfall environment communities represent a first step towards a comprehensive analysis of the socio-economic and agro-environmental effects of agricultural policy reform in the WANA region.

The new type of agriculture that could emerge as a result of reduced distortions in the output and input markets carries obviously less distortions in commodity and input markets. The changes in agricultural support policies could exert varying degrees of influence on the level and the mix of resources utilized in crop and livestock production in low rainfall areas. Overall, the changes should yield a positive impact on at least one sustainable development indicator (equity in Sidi Frej and the environment in Falha) despite some negative outcomes for specific indicators. It is therefore the outcome in terms of reduced income in both communities and its distribution in Falha that merits to be given priority for the respective policy-makers looking for the establishment of a sustainable rural development in the less favored areas relying on barley and sheep production.

Looking forward to further work on communities in low rainfall areas…

This type of analysis was undertaken to assist policy-makers in the WANA region get a better grasp of the linkages between agricultural activities on one hand and socio-economic and environmental impacts on the other hand. The linkages found in low rainfall areas are complex, reflecting biological processes on croplands and rangelands, variations in natural resource conditions, socio-economic and cultural factors, sector and macroeconomic policies and reforms of these policies. These linkages tend to be complicated even more due to the spatial and temporal variation in the effects of agriculture on incomes, equity and environmental sustainability within and between different sites, regions and countries. Additional work should be conducted to further understand the impacts of policy measures, and changes in those measures, on the critical triangle by looking at a larger set of communities in the WANA region, reflecting not only different agro-ecologies but also various policy environment and socio-economic conditions. The ultimate purpose of the expansion of this work is to provide information to meet the growing demand for generating information on the impacts of new policy, institutional and technology options so as to: (i) reduce the risks and improve the benefits related to current practices in the less favored areas of WANA; (ii) improve the targeting of programs that have a potential to yield win-win outcomes and reduce inequality patterns; (iii) facilitate the monitoring and assessment of economic, social and environmental interventions. This FEMISE-funded Project has begun work to help meet the demand for more information and analysis of linkages between the three corners of the "critical triangle" by developing an analytical framework, called the "community approach"[3] within which these linkages can be examined, and by identifying indicators to assist local organizations and policy makers meet the challenges of sustainable development. Specific areas of interest linking agricultural policy to rural development during a transition phase require a more careful examination. These include the impact of (i) targeted subsidy schemes for social reasons, (ii) broad trade and exchange related policies, (iii) rural finance and interest rate changes and (iv) pricing policies linked with environmental protection measures. There is certainly room within the current model structures built for these communities to explicitly analyze these types of policy reforms.

[3] This approach has a lot of similarities with the CGE approach that looks at similar reforms but at the national level and not at the village level.

Tables

Table 1: Type of scenarios simulated in the cross-community comparisons

Level of Intervention	No Reduction in Output Support	Substantial Reduction in Output Support
No change in input prices	**Baseline**	**Scenario 2 (S1)** Output prices down by: 25% in Algeria 20% in Jordan
Reduction in Input Subsidies	**Scenario 1 (S2)** Input prices up by: 20% in Algeria 30% in Jordan	**Scenario 3 (S3)** S1 + S2

Note: different values indicate different levels of intervention in the support to agriculture in Algeria and Jordan.

Table 1.1: Changes in land allocation to cereals

	Falha (Jordan) In du	
	Wheat	Barley
S0: Baseline Run	123	598
S1: Feed Subsidy Removal	112.2%	41.8%
S2: Output price support reduced	132.5%	37.6%
S3: S1 + S2	148.8%	34.3%

Table 1.2: Changes in livestock levels and herd composition

	Falha (Jordan) In heads	
	Sheep	Goats
S0 (Baseline)	2478	808
S1	2506	498
	(+1%)	(-38%)
S2	2385	648
	(-4%)	(-20%)
S3	1571	0
	(-37%)	(-100%)

Note: numbers in parenthesis are in percentage change with respect to S0.

Table 2.1: Income distribution effects of various combinations of policy reforms Falha (Jordan)

Scenario	Gini Coefficient
S0: Baseline Run	.31
S1: Feed Subsidy Removal	.34
S2: Output price support reduced	.35
S3: S1 + S2	.44

Table 2.2: Concentration of production and support for various farm types in Falha (Jordan)

	Shares of each farm type		
Farm type	Population	Livestock	Subsidy
Small	15%	4%	5%
Small-to-medium	15%	7%	9%
Medium	40%	29%	35%
Large	30%	60%	51%

Notes: While the population and livestock shares are derived from household survey data, the subsidy numbers are based on the model simulation results for the base-run.

Table 3.1: Potential environmental effects of various combinations of policy reforms in Falha

	Environmental Indicator
	Shadow price for Trees
S0: Baseline Run	8.02
S1: Feed Subsidy Removal	8.59
S2: Output price support reduced	9.11
S3: S1 + S2	10.14

Table 4: Impact of Policy Reforms on Key Indicators in Sidi Frej Community (Algeria)

Variable	S0	S1	S2	S3
Area in Cereals (ha)	15.1	2.1%	6.3%	11.0%
Off-farm Labor (man-days)	300.9	1.5%	-48.7%	-52.0%
On-farm Labor (man-days)	665.0	-15.2%	12.0%	11.0%
Sales of Storable Feeds (Kg/period)	381.7	-4.2%	-42.0%	-49.3%
Purchases of Feeds (Kg/period)	400.0	-26.5%	-42.0%	-50.0%
Area in Opuntia (ha)	6.8	-4.4%	-13.6%	-24.1%
Short-term Loans (DA)	104038	-11.6%	-31.3%	-40.3%
Sales of Livestock (head)	17.9	-1.2%	-6.4%	-7.8%
Rangeland Intake (UF)	574.4	-4.6%	-26.4%	-29.1%
Average Revenue (DA)	507058	-2.6%	-21.5%	-21.3%
Gini Coefficient	0.23	0.22	0.20	0.15

Note: 1US$ ≈ 75 DA.

Figures

Figure 1: Impact of Various Pricing Reforms on Falha Community Income

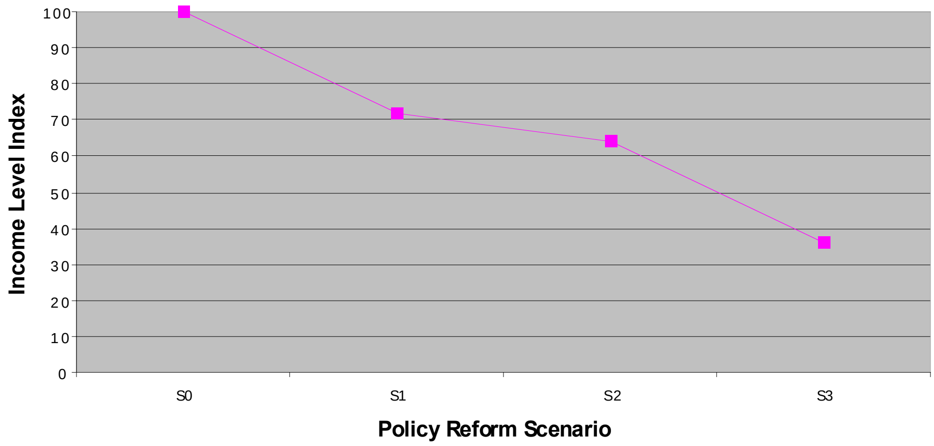
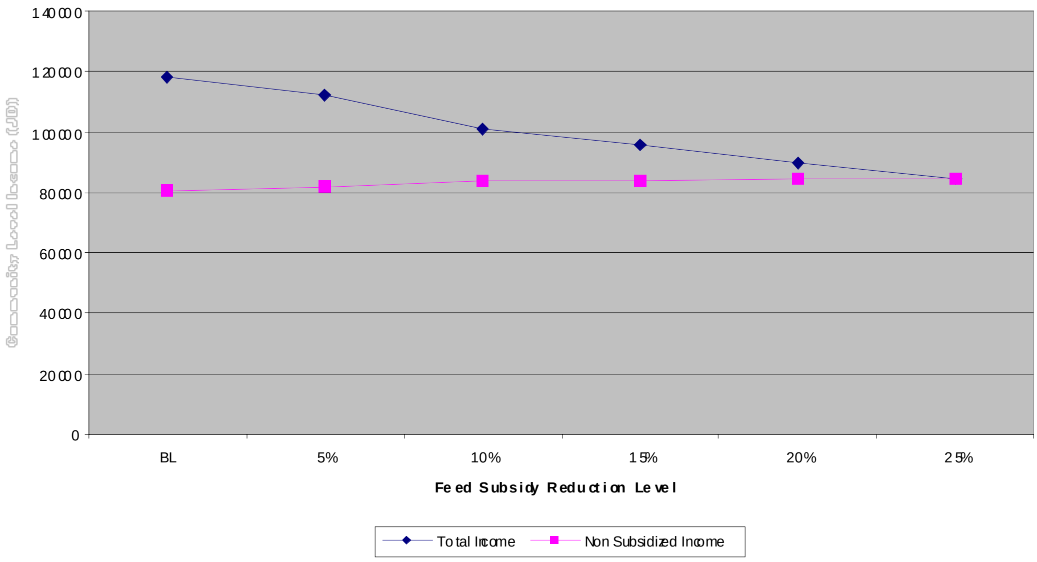


Figure 2: Impact of Feed Subsidy Removal on Income in Felha



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