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ASSESSMENT OF LIVESTOCK AND FARMING SYSTEM IN HARSH ENVIRONMENT - APPROACHES ADOPTED BY FARMERS THROUGH MANAGEMENTS PRACTICES

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Summary

A substantial of livestock production in the world takes place in harsh environments with high agro-ecological constraints and uncertainty in the availability of vegetation resource. There ate huge differences between North and South regions with respect to the socio-economical environment that conditions farmers' decision process and also to the priorities for the development of the livestock sector. Nevertheless assessments of real-life farming systems in varied harsh enviroments in both the areas have pointed out similar traits in farming practices, from which some fundamentals for assessing the efficiency of LFS in a sustainable development scope can be derived. These are mainly linked to risk management at both the whole farm and the livestock system levels, considered as an, integrated and complex system.

In this paper we will develop and provide an overview of the lessons from R&D work in a variety of harsh environments as a means of establishing some general considerations about livestock farmer practices. Farmers' risk attitude, especially in the management of biological resources, appears as a key factor to understand efficiency of LFS and to assess the potential research to contribute to the sustainable development in LFS.

Keywords: harsh environment, farming system approach, herd management, household system, risk management, efficiency, sustainability

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Introduction

During the first thirty years after the second world war, traditional systems in harsh enviromental have been quite neglected by the research/ extension services which were focusing on the increase of animal performance yield, with the genetic improvement of animal breeds and the enhancement of animal production technology, and the reduction of climatic risk, with t!he development of grass production and stored forage technologies. The belief then was that these systems required a similar approach to that needed universally for the development of agriculture world-wide. The difficulties that were met in having them adopted and effectively demonstrated in harsh environment conditions in the South as in less favored areas in the North were initially stigmatized as a result of the lag in education and the conservative nature of the traditional farmers in such areas, hampering the efficiency of technological transfer. This view was further denounced as too simplistic, thanks to the development of multidisciplanary research approaches both in the South and the Mediterranean environments in the North (Boyazoglu and Flamant, 1990). Since the second half of the 20th century, huge difficulties for adapting these systems to the general conditions of the society appeared all over the world; in the South, severe droughts and desertification affect pastoralists and agro-pastoralists in a large part the arid and sub-arid areas. Livestock farming in harsh environment - that provide more than 40% of the protein supply (FAO,1995) - is in a crisis in most parts of the world.

The need for a better account for the specificities of animal production in these environments led to develop new research areas for improving their biological and technical traits such as animal physiology in harsh conditions, genotype-environment interactions, range science and grazing ecology arid systems experiments for building adequate technical packages. Additional years were necessary for researchers and advisors to come into the view that, particularly in harsh environments, it was impossible to separate socio-economical issues from bio-technical issues when attempting to improve livestock systems at the real-life production units. The interest into interdisciplinary field research aimed at the assessment of the real-life farmer management practices as a basis for local development of livestock systems is a relatively recent trend both in South and in North (Gibon et al, 1996; Bounejrnate et El Mourid, 2001; Faye et Lhoste, 1999).

In this paper we will develop and provide an overview of the lessons from research in a variety of harsh environments as a mean to establish some general considerations to assess and understand the basis of livestock farmer practices at real-life farms. We concentrate on the livestock unit and farm level, but incursion into other dimensions will be necessary at several stages.

Farming systems in definitions and concerns

Constraints for agriculture in harsh environment reported in agronomic and socio-economic research works refer to three main categories in natural environmental conditions which restrain the productivity of ecosystems and the efficiency of their cultivation, and contribute to their sensitivity towards between years variations in weather conditions:

- climatic conditions such as extreme high or low temperature regimes, arid or per-humid moisture regimes, frequent drought occurrence, significant snow cover and frost.
- soil constraints to plant production (depth, fertility, texture, hydro-morphy, chemical constraints such as salinity, etc.).
- obstacles to access for mechanisation such as steep relief, wetlands, etc.

According to FAO/HASA data (2000), 76,3% of land in developing countries and 80,9% in developed countries would be subjected to severe environmental constraints for crop production: too cold (13%), too dry (27%), too sleep (12%) or with poor soils (65%)[1]. Dry conditions concerns more than three quarters of lands in northern Africa, western and central Asia, and more than 50% in southern and western Africa. But the most important constraint all over the world is the soil constraints that represent between 40 and 80% of land. Cold is limiting in North America, northern Europe and Russia. Topography is the major constraint in southern Europe and Japan. So, adverse natural conditions appear as the basic characteristics of harsh environments. Nevertheless, the role of human factors is also important. If natural adverse climate variation is the main background factor in arid, semi arid and dry sub humid regions, human abuses of the land (e.g. overgrazing, over cultivation..) and water resources can be considered as the main critical cause of desertification, through the processes of soil erosion, salinization and alkanization (Wu, 2001).

A main common feature in harsh environment is the prevalence of livestock production, based on a variety of animal species. Small ruminant systems are largely dominant in dryland areas in West Asia and North Africa (WANA) and also in mountainous areas in Europe. Cattle, buffaloes are dominant in many part of the rest of Subsaharan African countries and South

[1] http://www.iiasa.ac.at/Research/LUC/GAEZ/results/rtxt.htm

Asia, and camelios in desert areas. Beyond the diversity in the species used and the "extensive" systems in which fhey are managed, the common trait grounding the importance of livestock system in harsh environment is the capacity of animals to benefit land covers and feeding resources improper to the direct use for human consumption.

Controversies are periodically raised about the respective interest in "extensive" animal production in harsh environments versus intensive animal production for meeting the protein needs of the growing human population in the future. Nevertheless, many facts emphasise the importance of considering trie development of livestock systems in these areas and the conditions to their survival. According to United Nations Environmental programme (1992), drylands that are susceptible to desertification account for more than one third of the world and support more than 20% of the global human population (Wu, 2001). At worldwide level, extensive animal production in harsh environments is still providing more than 40% of animal protein in 1995 (Nardone et Gibon, 2000). Moreover in many irrigated areas in South Asia and WANA - non considered as harsh environment, there is a real danger of desertification due to the over or bad use of water & land resource and the current phenomena of global climate change.

The development and maintenance of livestock activities in harsh environment is mainly based upon the resistance of different types of domestic animals to harsh environment conditions, and their adaptive capacity to resist feed shortage periods, to move and explore different grazing places in time or alternatively to be kept confined in stalls (barns) year round. But, these intrinsic capacities of the animals, nor the technological ways for improving their production yield or again the feed resource are not sufficient when the question is to explain the maintenance of livestock systems in these areas or to assess the conditions for their survival arid, also their reproduction and viability over time. Given the importance of livestock farming systems in relation to creating, and now, maintaining important ecological and cultural systems and landscapes, in these harsh areas (El Aich and Waterhouse 1998), it is crucial to be able to understand these systems arid avoid them damaging their ecosystem by either over-exploitation or by abandonment.

LFS researchers developed to address livestock system development issues in a variety of harsh environments pointed out the necessity, for assessing the sustainability of livestock systems, to address real-life farmer strategies and management practices not only at the livestock system but also at the whole farm level (Gibon, 1997, Lhoste, 1994, Landais et al, 1993). Livestock systems appear as a component of more complex systems at farm level, and, to be efficient, improvements suggested to real life livestock systems must be consistent within the overall strategy of the farmer and the overall constraints at farm level.

As a contribution to the question of sustainable development of livestock systems in harsh environment, we illustrate this point of view from the results of an array of research works, involving strong interactions vs integration between a wide range of disciplines. The LFS researches reported in thé paper address a great variety of environmental conditions, but use a similar general approach, integrating human objectives and needs with technical knowledge derived from animal and biological sciences. The use of systemic modelling for linking socio-economics and technical systems is in effect a fundamental in such researches (Beranger et al. 1994; Dent et al, 1996).

Through a presentation of case studies over North and South countries, we propose to address the global operation of livestock and farming systems, and the way the resources are managed in a variety of harsh environment conditions in order to enlighten: (i) the contribution of such approach for understanding the main forces of adaptation of these systems; (ii) and the prospects and ways for their further development.

Diversity in the conditions and prospects for livestock systems in harsh environments

When the aim is to address the prospects for livestock systems in harsh environment as a component of the whole farming system, as in this session, it is important first to assess the basis of livestock farmer practices at real-life farms, in constant reference to the conditions of their social, institutional and natural environment. But the first outstanding point is the complete contrast between the North and the South with respect to both its situation and dynamics of change. Significant well-known differences result first of all from the general dynamics of human populations leading to a search for a huge enhancement in animal production volumes in the South. In the North, production is generally in excess, as a result there are entirely different situations for both dynamics of change in the agricultural systems and conditions for livestock development.

For illustrating the specificities of livestock farming conditions and practices in harsh environment and exemplifying their similarities and differences according to local conditions, we selected an array of LFS research works run in a variety of North and South regions.

At the North ...

In the more frequent conditions (non harsh environment), livestock systems are currently intensive, within livestock specialised farms which combine specialised animal breeds selected for high production yields with feeding system based essentially on stored forages (grain, hay, ensilage) and concentrates. Extensive livestock systems still persist to some extent in harsh environment, such as mountains (Scotland in UK, Pyrenees and Massif Central in France, etc.), despite their share in the'overall animal production is currently low.

The two interdisciplinary research works reported address mountain conditions in France, in environments where common grazing lands are the rule, such as Central Pyrenees or without common lands, as the Causse plateaux (Mejean and Larzac). In the Central Pyrenees, main constraints in natural environment lie in the land aptitudes, with steep slopes and difficult access (altitude range between 400-600 and 3800 m a.s.l.), and the climate, with cold and snowy winters (average annual rainfall over 1500: mm). In the South of the Massif central, the Causse region is a region of calcareous plateaux of poor soils, limited annual rainfall, and hard winter climatic conditions linked to altitude (700-800 m for the Larzac plateau and 900-1000 m on the Mejean Causse).

Till the abandonment of crop cultivation in the 1960s, the local Pyrenean agro-pastoral systems benefited concomitantly privately owned cropland and meadows and collective grazing lands owned by village communities, covering a wide altitude range. Sheep and livestock were Important components of the system, not only for their milk, meat and wool production, but also as a source of draught power (cattle) and manure for cropland fertilising (sheep and cattle) (Gibon 1981). Traditional systems were characterised at farm level by very limited input other than intensive family labor, and at community level by a set of rigorous explicit and implicit social rules organising not only collective but also private land resource allocation and use, and coordinating the individual family farm operation (Balent, 1987; Balent et Gibon, 1992). As in many other mountain regions in Europe, an important decrease in agricultural pressure on the natural grazing resource occurred during the second half of the 20th century, in parallel to the specialisation on livestock production and the conversion of cultivated cropland into meadows. Since the 1960s, average farm size steadily increased (up to about 20 ha of private agricultural land and 20-40 livestock units) thanks to emigration to towns and re-conversion of part of the agricultural population. Farmer's strategies diversified since the 1980s, both in terms of systems of occupation at the families, with an increasing share of pluriactive family farm, and of an increased variety in production strategies. The majority of the herds remain nevertheless constituted of local hardy breeds of sheep (Tarasconnaise) and cattle (Gascome), well adapted to transhumance on altitude grazing land and to large seasonal variations in feed resource availability.

In the Causse region, local farming systems associate cereal and forage crops cultivated in the few areas of the territory with better soil (red clay) argil and grazing on the calcareous grasslands. Since the 1960s, the dynamics of change in the Roquefort area was supported by the genetic improvement of the local breed Lacaune into a specialised dairy breed, and very active advisory services and fatiner unions which promoted the adoption of technological innovations earlier and more rapidly than in other regions in France (animal performance recording, Artificial Insemination etc.). The local diversity in land use and farm technical management patterns, and in strategies at the family farm level nevertheless maintained and even increased with the development by some farmers of various initiatives, such as direct lamb sales to consumer and agro-tourism. Similarly, within, the UK, whilst there have teen large changes in the technical and labour inputs, and changes in the type and marketing of the output, the underlying system of all year around grazing by traditional hardy breeds of sheep has been maintained, as farmers perceive few alternatives to the core system (Waterhouse, 1999), and the importance of sustainable livestock production 10 tourism is becoming increasingly valued.

The main evolutions of the productive systems are concomitant to the European societal and policy change. The Common Agricultural Policy (PAC) in the European Union recently acknowledged other functions than food provision for animal agriculture in the society (Sorensen, 1997). The main characteristics in the development context of livestock farming in the North harsh environment are the need to face the threats is on environmental and ecological sustainability of land use arising from a past phenomenon of land abandonment and to contribute to sustain-socio-economically the development of rural areas (McDonald et al. 2000). For all systems, the main current pressures arise from market or institutional policies and farmers orient their systems to benefit from the maximum support and reduce the market risk (Wampfler, 1994).

At the South...

From the North Africa to the Sub-sahelian areas (from the Mauritania at the west to the Tchad at the Cast), drylands characterized with less than 350 mm of rain and periodic drought, are in majority the domain of agro-pastoraus ts, deriving their incomes from both livestock and crop production.

These agro-pastoralist systems include a wide range of production systems, from semi nomadic systems (as Peuls in Sub Sahara, Bedouin in West Asia, Bahimas in Uganda, etc.) to sedentary systems (agricultural farmers who consider livestock as an asset or herders who diversif their agricultural speculations) which vary in intensity. The main difference between agro-pastoral and intensive crop and livestock systems is that the former consists of larger herds and usually relies on some kind of communal pastures or rangelands. Intensive crop and livestock systems are more frequent as land shortages force agro pastoralists to intensity their produclion. So in Asia, where land shortages are severe (as in India), the typical livestock production system is a smallholding integrated crop-livestock farm called "backyard system" (Bravo-Baurnann, 2000). But in many developing countries, during the colonisation period and subsequently the national land reforms, many governments focused their efforts, to settle nomadic or semi nomadic peoples with large research and development programmes which aimed to increase incomes from cropping systems. These policies resulted frorn many objectives: tax collection, cereal food security, control of social communities and territories, benefit of land opportunities, etc. but caused major changes in ecosystems and irreversible change of traditional systems (Abbab et al, 2002; Ben Saad A., 2002).

If the traditional systems were based on common pasture controlled by tribal communities (that ensured rules of use of pasture resource), now there are increases in use of crop residues in the animal diet as feed grains and other concentrates are becoming common across the vast semiarid 'steppe' zones (100-400 mm annual rainfall) stretching from Morocco to Mongolia (Nordblont at al, 1997), but also in Sub Saharan countries (Corniaux et al, 1999). In West Asia and North Africa (WANA), it is observed the extension of stored forage in situ (atriplex, acacia, cactus,...). Fodder crops (green barley, bersirn, sorghum, vetch, oat) is limited to irrigated areas. The majority of agro-pastoralists extend cereal crop production, mainly wheat for self; consumption and barley for animal feed, on marginal lands although cereal yield vary considerably from year to year -depending on the total amount of rainfall and its distribution. But one common factor in WANA is the drastic reduction of resource rangeland to cover feed requirement -with a decrease from 65% in the beginning of the 20th century to less than 10% (Nefzaoui, 2002) and the structural component of supplementation in the feeding system, inducing an increase of risk market and large dependence of public support during drought conditions.

Nevertheless, in many places due to their isolation and harsh conditions, as in the High Atlas (Morocco), Tataouine (Tunisia) or North-East of Jordan, the common range land remain an important pillar of the systeni as in many (agro) pastoral societies in sub Sahara, with a very specific mode of life and of functioning, deeply established or rooted in cultural traditions. In the North-East of the Mbarara District (Uganda), the cropping system is limited to allow for family food needs and the livestock system is traditionally based on grazing pastoral rangeland. The main risks are climatic risk but also social risk. The des-aggregation of the social linkages due to the societal and institutional changes increase the vulnerability of the herders due to failure to respetct the rules of access and use of common rangeland and the increasing pressure on land through the cultivation of marginal land.

In the South, the socio-economicas and ecological sustainability of livestock farming systems in the harsh environment appear as fundamental to fulfil the majors stakes of development as employment, rural household viability, protein supply, etc. The social, institutional and policy change in the South induce deepened changes to traditional systems with an increasingly dependence upon public support and market due to the land degradation in the WANA and with frequent social conflicts in Sub Sahara due to the weakening of traditional mode of regulation. Moreover, increasingly water shortage problems pose questions to researchers and policy makers researchers and policy makers to consider water conserving production systems, and in many cases this will involve traditional extensive systems rather than intensive systems.

This sort presentation of the main traits of the agricultural systems and their historical development in a wide array of harsh environments emphasises the importance of the conjunction between top-down pressures from society and policy at national or regional levels and the local bottom-up pressures arising from individual farmers and rural communities. The later encompass a range of phenomena at various levels of organisation. In the paper we concentrate on the individual farm, for enlightening the specificity and diversity of farmers practices at the farm and herd level in harsh enivironment.

Bio-technical management of livestock systems in harsh environment

The worldwide process of agriculture intensification over the period 1960-1990 led to animal research focussing on the use of advances in scientific knowledge of the biology of domestic animals to design breed improvement programmes and management techniques aimed at the maximum expression of the production potential of the individual animals. As a correlate, agricultural policy and technical advice to farmers has been for a long time based on artificialisation (agro-industrial feed supply, synchronised heat, use of ram, etc.). The unsuitability of these principles for the development of animal production in harsh environments was demonstrated later, especially through failure of technological transfer but research on specific technology required for harsh environment was limited for a long time.

This is one of the reasons of the expansion of field animal research at real farms and the development of system modelling approaches based on farm monitoring methods associating in the course of regular visits over the year, herd, performance recording and farmer interview about his management decisions (Gibon, 1981; Gibon at al., 1988; Faye et Lhoste, 1999), but also participatory approach to encompass the community level (Bounejmate et al., 2001, Malki, 2001). These long lasting field researches -conduced by INRA in Central Pyrenees and Massif central, ICARDA and national research institutes in WANA and CIRAD in Uganda-allowed to identify and to assess the management practice of the farmers and to model the technical operation of the livestock systems in harsh environment.

Results of field observations pointed out similarities in the traditional production patterns for sheep and cattle in harsh environment as follow:

- the use of local hard breeds as Gasconne and Tarasconnaise in Pyrenees, Lacaune in Massif central, Barbarine in North Africa and Awassi in West Asia, etc., or again of multi-purpose breeds (such as Brown Swiss in Central Pyrenees or Ankole in Uganda); - the herd is often multi-species with different production characteristics and with specific diet. It is frequent to associate small ruminants, goat and sheep, in the same flock or in cattle herd. Goats are well known for their hardiness and ability to handle stresses of nutritional deprivation. The different species use different species and components plants at the plot level.

- the production of a multiplicity of animal products at the herd and farm level. Whilst draught power and manure for fertilising are no longer strategic in most of the North Mediterranen systems, a large variety in animal product can still be observed, with frequently associated production of cheese, fattened and store animals, and young and adult females for reproduction. In North Africa, sheep flock produce is essentially fattened and store animals, plus cheese and milk in West Asia. In pastoral system in Uganda, to the dairy product, it is necessary to consider the manure for biogas, the rent market for animals, etc...

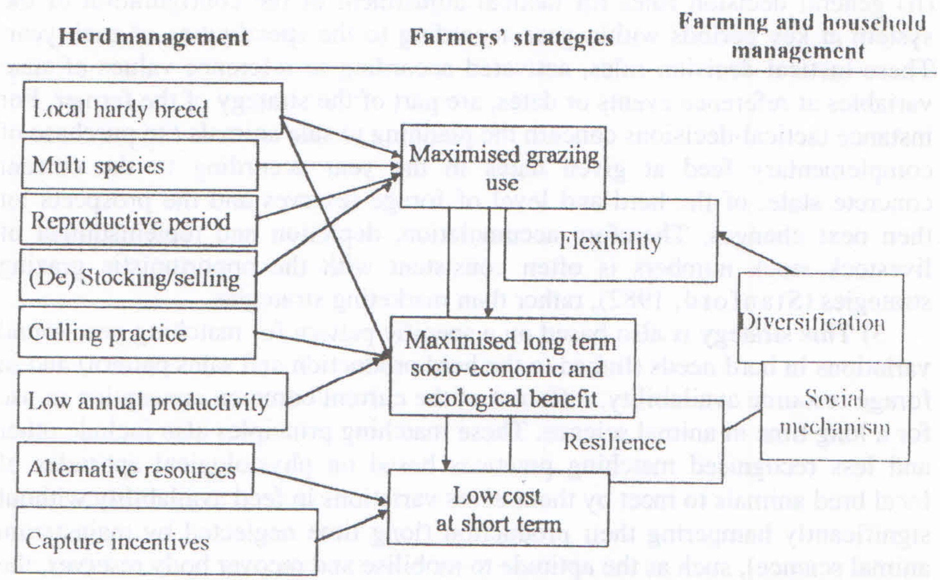
- various culling practices: that depend on the productivity over the years (North) but also cash flow management (sale of the more reproductive female to re-constitute the flock in WANA) or absence of practice (with natural adjustment) in pastoral Sub-Saharan area.

- long lasting reproduction in Sub Sahara and Central Pyrenees.

- complex spatio-temporal patterns of use of a variety of grazing lands available at the territory, including transhumance on altitude range in the North and common dry rangeland in the South, but also the hierarchical and complementary use of the resource due to the feeding preference of each specie in the herd (Ben Salem et al, 1993).
- winter/summer feeding reserves based on home produced saved forage (as meadow hay or silage in the North or straw, stems, etc. in the South) and concentrate.

These empirical observations at the herd level constitute essential materials to point out general assessment on farmers decision systems that are the basis for conceptual models of the traditional strategies for farmland herd management (Gibon and Duru, 1986; (Gibon et al., 1989; Ben Saad, 2002; Alary et al., 2001). It is proposed to highlight main traits of the decision system (Figure 1).

Figure 1. - ATTRIBUTES OF SUSTAINABLE FARMING MANAGEMENT IN HARSH ENVIRONMENT



1) First the main objective followed in livestock production strategies is to maximize benefit from the natural resource, within the limitations imposed by the natural environment constraints. Multi species herd composition is one way to explore the overall potential of the pasture. In sheep systems, out of season

reproduction with principal lambing period in autumn appears also the best compromise for reaching this objective in the Pyrenees. Thus a key factor of control appears to be the natural or managed lambing/calving period fitted to provide sufficient resource or improved protection to the new-born animals during the crucial period of pregnancy and lactation.

2) However, due to erratic climate change in harsh environment, it is hardly possible to obtain the technical optimum of lambing during a short period and livestock keepers need also to adjust permanently animal numbers to match available feed resource. The decision system appears as a complex hierarchical system designing an adaptive strategy thanks to a series of sequential decision making processes. The general configuration pattern for the structure and operation of bio-technicai system acknowledge as a fundamental the climatic variations between years and their potential effects on the elaboration process of the annual herd production. Animal production strategy is therefore made of (i) a general provisional plan of spatio-temporal organisation of the relation between herd reproduction, production and selling patterns and the patterns of land use for grazing and conserved forage reserves, (Ii) general decision rules for tactical adjustment of the configuration of the system at key periods within year according to the specificities of each year. These tactical decision rules, activated according to reference values of state variables at reference events or dates, are part of the strategy of the farmer. For instance tactical-decisions concern the planning to sale animals / to purchase of complementary feed at given dates in the year according to the current concrete state, of the herd and level of forage reserves and the prospects lot then next changes. Therefore accumulation, depletion and replenishment of livestock stock numbers is often consistent with the opportunistic grazing strategies (Stanford, 1982), rather than marketing strategies.

3) This strategy is also based on a specific pattern for matching year-round variations in herd needs (linked to the herd production and sales pattern) and in forage resource availability, different of the current common conception in use for a long time in animal science. These matching principles also include other and less recognised matching practices based on physiological aptitudes of local bred animals to meet by themselves variations in feed availability without significantly hampering their production (long time neglected by mainstream animal science), such as the aptitude to mobilise and recover body reserves, the compensatory growth phenomenon, etc. In particular, the survival of the breeding female in the face of very harsh, and variable conditions is a priority.

4) The objective is managing without resorting to external and, costly inputs despite climatic uncertainty. The farmers consider it as normal that variation between years in the annual level of herd products (within a given

range) and at the same lime prioritise flexibility as the major quality for their bio-technical system. This quality is gained partly from the multiplicity of animal product types which help to limit the consequence of bad seasons on the system operation, but also specific herd management practices that contribute also to this objective (see next section).

5) Strategies are always designed for coping easily with a given range of climatic variations between "normal" years, whose wideness varies according to individual farmers risk perception and acceptance with respect to climatic uncertainty and institutional support, but never include the capacity to cope with exceptionally bad climatic years.

So, heterogeneity of production patterns between animals and through the year constitute a key factor of resilience in harsh environment and it is well accepted in traditional sheep or cattle herds (Gibon, 1994), and also within years for a given animal. And capacity to maintain a flexible but suitable timeliness during a long life-time span and life-time performance appear the main traditional farmer criteria with respect to individual performance. To ignore this key-factor can lead to inconsistent diagnostic. For instance, pastoralists have often been considered irrational in range management due to the high number of animals. But the large number of poorly fed livestock is to hedge against risk - sometimes by loaning out livestock- in preparation for recurrent drought and their inevitable high mortality.

Because of this fundamental difference in the hierarchical approach of the herd spatio-temporal operation in harsh environment, from individual animal to whole herd level, the application of technological innovations for improving herd productivity can be also counter-productive. As an example, in the Pyrenees, advice for improving flock production from a higher feeding regime for the replacement ewe lambs resulted in an increase in mid-winter lambing numbers, a source of depressed productivity in some herds because of the increased perinatal mortality and reduced growth of mid-winter born lambs in the traditional system conditions (Gibon et al., 1984).

This equilibrium between natural conditions and animal (de) stocking may be perturbed by public support. In the WANA, "drought management" policy support causes negative impacts on natural pasture - due to the overgrazing during low productive period of rangeland- and increasingly dependence on purchased inputs. But farmers maintain opportunistic feeding strategies to benefit of the available resource. In Jordan, the grazing period fluctuates between 6-8 months for a good year to less than one month for a drought year. Farmers usually exploit first the common pasture before using their own resource.

Other topics of importance such as grazing practices and grazed ecosystems management have not been addressed. But, in the light of the examples reported here, the principles for the organisation and management of traditional livestock systems in harsh environment appear to be very far from those grounding the development for mainstream systems where the principle is to correct the constraints in the environment of the animal which limit the expression of their biological production potential. Animal research on physiology and adaptive traits of animals within harsh environment appears as very necessary but no sufficient for efficient support to the improvement of such livestock systems, and the practices for herd management include knowledge (i) at upper spatio-temporal levels of the herd, operation currently little explored by animal science (animal lifetime span, whole herd production patterns, ...) and (ii) at different organisational levels of bio-technical systems (interaction animal-resource, animal-farm livestock-regional livestock, fodder stock, etc) and of bio-economic system (shift of the herd and family task during the grazing period, milking operations for sale or self consumption...).

From these various examples, a major common trait of farmer strategies in harsh environments appears to be the variety within the same farm of the risk-coping practices in order to support the huge between-years variations in climatic conditions and to face years with bad conditions to enable system survival. They include regulations at the livestock unit per se, such as selling part of their livestock, herd seasonal migration but also at higher levels in the family-farm organization and operation.

Farmer strategies at the family farm level

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

The household systems may also associate traditional system and intensive livestock systems based on improved meat/milk breeds, as in Pyrenees (Gibon, 1997) and Massif Central (Gibon et al., 1984). These two systems are articulated: if the intensive system in harsh environment is allowed thank to the security and resilience of extensive system, the extensive system benefit from the higher income in the intensive one.

Another characteristic of the traditional system in harsh environment is the diversification in off farm activities. In one community of Sidi Bouzid (Tunisia), 82% of farmers benefit from immigration revenues or commercial activities, that, represent 37% of the total farm income in 1999[2]. Wage labor and self employment in off farm activities may be considered as risk absorption strategy during times of stress rather than profit maximization. In the South, the income are often reinvested in the livestock system, mainly to increase the live asset considered as the main saving asset in the South. However, the off farm diversification depend on many factors: farm size, social capital, employment opportunities for men and women, cultural factor.

The array of regulations for meeting climatic variations bei ween years encompasses several levels in farm management up to the family-farm level that point out the role of both the moment in the farm household "trajectory" (i.e. the consecutive stages in the household lifespan and the correlative change

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

in the farm structure - Capillon, 1993) and the changes in economical and social environment on the change in production strategies and its possible impact on the efficiency risk coping strategies at farm level. An analysis of the diversity of the Pyrenean livestock systems according to family parameters revealed variations according to the date of installation and the future (succession or no succession). For the youngest farmers, the main current strategy is surprisingly on traditional logic for utilising the low-cost grazing lands. But the trend -when the family expands- to enlarge the flock and to diversify animal products to benefit market opportunities in order to lace the increasing family needs often lead them at a next stage to invest in building animal barns of increased capacity and to modify labour power allocation. Both factors limit the resort to natural resources available at both the farm and the common lands, and in turn call for additional changes in livestock systems (Gibon, 1999). In Sub Saharan pastoral areas, inheritance mechanisms at the household level allow the reduction in social pressure al the farm and family level (Alary et al., 2001).

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

Understanding the farm-level strategies and their changes need also to consider a wider system (of a "pluriagent" type) issuing from the traditional social organisation of the pastoral communities. In sub Saharan pastoral areas, the risk management, strategies are mainly established at the extended family and community levels (Balent and Stafford Smith, 1993; Swalow, 1994; Park, 1993) and include many forms: 1) group insurance mechanism, including group inheritance of livestock to ensure inter generational and inter household sharing asset; 2) Sharing of food and hospitality: household suffering prolonged stress may rely on family members, no subject to the same stress (Scoones el al, 1996); 3) Livestock tenancy arrangements with different forms of agreement; 4) Community credit societies to finance agricultural assets; 5) Combination of collective and individual property right on pastureland with different level of social organization (group, village community, region).

The analysis at the farm level points out different combination of the strategies in the livestock farming management in harsh environment and concludes to a heterogeneity in individual patterns in such farming systems and question higher levels of organisation as the extended family or the community (migration, life expectancy, law of succession,...). But diversification appears clearly as a common strategy of risk management (diversify the portfolios) at each level of organization in harsh environments (Figure 1).

Trends observed in both North and South contexts emphasise also the pressure from the economical, institutional and political environment (such as land privatisation, drought mitigation policies, etc.) on the lifetime changes at the farming systems that can lead to disorganise risk coping strategies and threaten the long term sustainability of the natural resource. The weakening of traditional modes of regulation for the use of collective pasture appeared to be an important facilitating factor of such an evolution: it encouraged "individualist" behaviour, and a global lack of care for the land resource sustainability (Balent et al., 1992; Chaherli et al., 1997). Therefore, if the main key factors of sustainability of these systems are linked to the adaptation and flexibility of farm-household strategies to the climatic conditions with an acceptance of deviation from the technical optimum, the evolution of the farming system in these areas is also linked 1) to the capacity to develop risk absorption strategies at the household levels, and 2) to institutional and societal changes at an upper level of the organisation of the agricultural systems.

Development of system modelling approach

LFS research is based on a conceptual model of the whole livestock farm which represents "a duality between the view of a farm as a human activity system and the view of a farm as a productive process" (Gibon et al, 1999). This conceptual approach of the whole farming system in animal production science stimulates the development of holistic simulation modelling. Many classifications of models in animal sciences have been established (Pittroff, 2002). We can mention two models focusing on the complex interaction between animal system, available resource and human objectives: (1) the decision support system that refer essentially to the adaptive and sequential character of the farmer's decision process in managing the balance between forage offered and required, and to the sensitivity of results to climatic conditions (Gibon et al.,1989; Herrero et al, 1997; Duru et al, 1998); (2) bio-economic model based on the integration of biophysical model with the economical and environmental models (Conington et al., 2000). The main objective of these models - by linking livestock information system and whole farm models -are to support long term management decision and understand the multi strategies of the farmers.

The simulation system representing the biology of pasture includes mechanistic models representing: 1) pasture growth, structure and quality; 2) an individual ruminant digestion and metabolism energy model to test nutritional strategies; 3) a population model describing management practice at herd and flock level (stocking rate, sales of animals, mortality or replacement, calving interval, etc.), which determine animal number, their age or physiological state classes. Individual mechanistic model can be used to improve the understanding of particular part of the system and the strategies (Herrero et al, 1997). But it should be noted that this model derived from ecological or agronomic models based on physiological plant, grass land growth according to climatic and soil conditions and variations or simulation models of selection and crossbreeding strategies operate on a low level of aggregation.

The recent bio-economic whole farm modelling framework based on agro-ecological and socio-economic parameters aims to have a better understanding of the effects of agricultural policy on the farmers' supply response (Barbier, 1988; Nordblom, 1994, Jacquet et Pluvinage, 1997; Deybe D., 1998) and explore the resource use and economic implications of the competition and complementarities involved in crop & livestock production in order to illustrate the potential development pathways of crop-livestock systems on the face of social, institutional and economic change (Wyatt et al, 2001). These models have been applied and tested under various agro ecologist conditions (dry and humid tropical lowland and hillsides) in different countries (i.e. Algeria, Mali, Burkina Faso, Costa Rica, India) to assess the impact of sectoral or national policy on the adjustment of land use and technology choice. This modelling approach is currently being extended to many directions: a more detailed approach of farm types, the development of risk coping strategies, establishing procedures for aggregate analysis at the regional level (Kruseman, Bade, 1998), the development of village/regional models to account for interlinked transactions and communal management of resources (Barbier, 1998; Alary et al, 2002), and the increasingly recognized role of non agricultural income in farm household decision making.

In harsh environment, the application of simulation models may be of greatest interest and benefit to understand the multitude and complex relationships between the components. But climatic and economic conditions in harsh environment, even also political conditions in developing countries, change in erratic, unpredictable way and frequently the complexity of the global dynamic in the time dimension is poorly understood. In the literature for agricultural economics, farmers are assumed to want to minimize risk in adoption of new technology. One major way in which farmers reduce risk is by increasing diversity either within the farm systems (Roumasset et al., 1979) or outside the farming system. Risk refers to situations where one can attach probabilities to the occurrence of events influencing the outcome of a decision. Uncertainty refers to situations where one cannot attach probabilities to the occurrence of the events. Today, attention is paid oh the personal beliefs of actors about the occurrence of events and the majority of recent models of individual decision behaviour are based on the expected utility hypothesis. But few studies include evidence about the different nature, frequency and perception of risks and how farmers manage the different risks over years.

In such environments, due to the major social interactions of the system at the community level, risk attitude is also function of social issues and social uncertainty relating, for instance, to family events (disease, death, etc.) at the farm level and to property rights at the community level. The choice of new production techniques depends less on supply aspects than demands criteria related to differences in structural and behavioural farm household characteristics (Binswanger, McIntire, 1987, Von Keulen et al, 1998) and the constraint of flexibility to respond to frequently changing circumstances. The assumption of sequential decision making can be use to address aspects of flexibility and factor substitution (Ruben et al, 1998). Recursive and stochastic programming is sometimes used to solve this model (Romero and Rehman, 1989).

Other limitations are inherent to optimisation: 1) absence of a detailed specification of the decision making procedures at the farm level, neglect of other objectives than profit maximization, etc.; 2) resource allocation is strictly based on best technical means, technical optimum that does not necessarily ensure efficiency and sustainabilily of such systems in long term. Priorities for various objectives -as has been seen above- are driven by perceived needs and risks within a society and for a given environment. Utility function is usually a highly "volatile" measure (Schoemaker, 1982) and change in conjunction with changes in altitude and behaviour. In harsh environment, crises and changes in social and environmental frameworks are common events. Moreover in this modelling approach, reactions to institutional change (rural financial markets, infrastructure, land rights) are not well taking into account in the medium or long terms due to problems of risk assessment.

Moreover tip bio-economic models are mainly conducted by socio-economists or agricultural economists and decision support tools by agronomists, without interdisciplinary work. There is sometimes a lack of sufficient knowledge of genetic mediation and physiological control of growth and reproductive processes and lack of appropriate data for validation and model specification (Pittroff, 2002). Current quantitative knowledge about the underlying biophysical relationships of such processes in harsh environments is sometimes insufficient (Hengsdijk H. et al., 1998). All these considerations call for more coordination between the different modelling approach to improve the analysis of the farming system.

Implications for the research

An appraisal of the evolution of research and society attitudes

The understanding of the current implication for research of these specificities in the real-life livestock systems in harsh environments calls firstly for an appraisal of the evolution of research and society attitudes with respect to their development.

The institutional and political changes linked to societal/social transformations in the various places, together with new economical rules (globalization), contributed to changes over time in the perception of these traditional systems. In developing countries, it is now recognized that in many places policy objective of settling pastoral people, enhancing food, self sufficiency and increasing commercial output of livestock from the rangeland contributed to problems because they reduce incentives for prudent management by farmers and herders. Problems induced by the "drought management" policies in the WANA region and in sub Saharan with the restocking projects are widely reconsidered and most governments are now recommending revised policy objective such as decentralized administration, empowerment of resource-user groups, food security and conflict management regulation. In the North, the agro-environmental measures in new European policy appear to advantage these traditional systems or at least recognize their effectiveness and importance for the new agricultural orientations (Gibon, 1994).

If livestock have been considered for a long time as responsible of the degradation of natural rangeland, then the flexibility and mobility of livestock - by the proper accounting for the temporal and spatial variability of rangeland production- appear today as invaluable attributes in appropriate management of these high risk environments. Now many; researchers emphasize the co-evolution of natural space with human activities and question the last paradigm (Dodd, 1994; Mace, 1991, Perevolotsky et Seliman, 1998) and stress how grazing is important to maintain i biodiversity and biotic characteristics (El-Aich and Waterhouse, 1998). These range ecologists and social and animal scientists have concentrated on the variability of rangelands, the resilience of rangeland ecosystems and the adaptability of pastoral societies.

Therefore, both in South and North, new pressures arise for animal research reconsidering its contribution to the development of livestock production in harsh environments and their interactions with human and wildlife ecology.

Progress in research frameworks

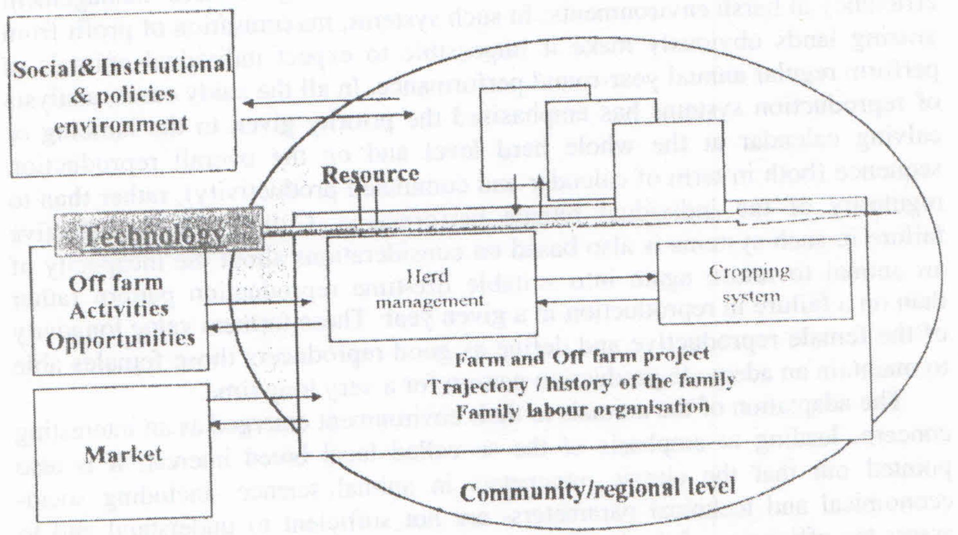
In order to suggest some directions for progress in the support to sustainability of their development, we will attempt to give an overview of the advances gained and the gaps in current knowledge that can be identified.

1) The analysis of farmer management practice and herd performance in traditional systems has pointed out fundamental differences in the conceptual basts currently adopted in animal science and those used by the local farmers for an efficient management of the performance elaboration process at herd level. In traditional practices, concerns such as the homogeneity of individual animal performance, the synchronicity of the individual fernale reproduction and production patterns, as the search for a year-based regular parturition interval for individual animals are given much emphasis. Many examples could be evoked that support the evidence of the inadequacy of a careless application of these classical technical references for assessing of herd management efficiency in harsh environments: In such systems, maximisation of profit from grazing lands obviously make it impossible to expect individual animals to perform regular annual year-round performance. In all the study cases, analysis of reproduction systems has emphasised the priority given to the lambing or calving calendar at the whole herd level and on the overall reproduction sequence (both in term of calendar and cumulated productivity), rather than to regularity of the individual female performance. Culling for reproductive failure in such systems is also based on considerations about the incapacity of an animal to return again into suitable life-time reproduction pattern rather than on a failure in reproduction in a given year. These farmers value longevity of the female reproductive and define as good reproducers those females able to maintain an adequate production pattern for a very long time.

The adaptation of the animals to their environment emerged as an interesting concern, leading to emphasis of the so called local breed interest. It is also pointed out that the classic parameters in animal science -including socid-economical and technical parameters- are not sufficient to understand and to assess the efficiency of the livestock system and emphasize the research of new indicators that value the specificities of these systems. In particular, the complex role of changing animal-plant interactions in such systems at the different level of organisation and over the years is now more fully appreciated.

The understanding of the real practices of farmers, their management know-how, their objectives and needs appear essential to assess the efficiency and sustainability of the whole farming system and also to develop appropriated solutions to their constraints. In this prospect, flexibility and resilience appear as the key factors enabling response to frequently changing circumstances. Two examples may illustrate this point: 1) trypanosomiasis control techniques have well been accepted, allowing pastoralists in Tanzania and Nigeria to make greater use of natural pastures in the affected areas (Jabbar et al, 1990); 2) cactus plantations have known a large success in the WANA, due to its multipurpose characteristics: it fits well in crop-livestock systems, helps in controlling soil erosion, in overcoming the need for watering animals and supplementing the poor quality diets (Nefzaoui et al, 1993; Ben Salem et al,1996), without considering the fruit harvesting that procure cash to pay school fees. So the success of new technologies are greatly dependent to the way that they modify flexibility or opportunities at the herd and farm level, and also at the community level (Figure 2).

Figure 2- - THE HIERARCHICAL LEVELS OF SOCIAL ORGANISATION OF THE FARMING SYSTEM TO TEST NEW TECHNOLOGIES



2) The failure of a number of R&D projects in these harsh environments has led to more integrated and deeper research work involving multi-disciplinary teams of biologists, agronomists, animal production scientists,

economist and sociologist, or even anthropologist, or ethnologist. The applications of system modelling and system analysis techniques developed in animal science as research tools and decision aids in support to the development of the animal sector (Gibon et al, 1999; Pittroff et al, 2002) emphasise the role of interdisciplinary research for enhancing the adaptation of livestock systems through communication between livestock farmers and society (Sorensen, 1997). The conceptualization and the integration of all these analyses has led to deeper study using the systemic approach, where the main objective is not the assessment of a technical or economical optimum but the representation of the real decision process: technical management, adaptive management, etc. Where there is a development objective, these studies allow better assessment of the possible impacts of techniques for controlling reproduction which might be proposed to the farmers (e.g. synchronizaton of oestrus, flushing), to understand the reasons for the failure of some attempts at development in this field and propose accompanying measures to obtain an improved efficiency in reproduction control. It is now recognized that improving resource management in a risky environment by using technology is often impended by non technical problems related to farmers risk management, property rights and inadequate policy context. Models results suggest that significant improvements in whole farm productivity and rural livelihoods can be achieved through better packaging of existing technologies and implementation of appropriate economic incentives and policies.

But the assessment of existing farming practices and the development of innovative management systems call for the development of more specific and integrative research works in order to (i) integrate the biological knowledge of animal and vegetation resources into models consistent for their integration together with the management models proposed and (ii) emphasize the trade offs between short term welfare -with high degree of reaction to ecological conditions- and concomitant long term productivity of the pasture and herd management in a risk minimization strategies over the long term and (iii) consider the different social and geographical levels of organisation within the time dimension.

In these research frameworks, theoretical or conceptual models may not prevail on the establishment of real decision tools that can be applied for the development of new strategies of rural development (Abbab et al, 2002).

3) The sustainability of the whole farming system also depends on strong and complex strategies at the family level with individual and common interests. This multiple interests call for the introduction of farm household specific characteristics and bargaining mechanisms at intra-household but also community/village level to improve the analysis of decision making procedures

for resource allocation and technology adoption (Ruben R. et al, 1998). In the WANA area, with increasing emigration of men and of farm activities, the implication of women in the farming system becomes greater and reinforce the importance of analysing the different adaptive management issues related to family and social organization and objectives, to evaluate their effectiveness, opportunities arid environmental implications. One of Chayanov's insights was also to see the importance of the domestic cycle in determining the margin in agriculture.

4) In harsh environment, the individual unit is not always appropriate due to risk minimization considerations (both ecological and political risk) at the collective level. "Individuals have individual incentives to produce and submit to institutional and collective controls over productive behaviour" (Park, 1993). The results gained when adopting such an approach in harsh environments show that coping with risk and uncertainty appears most of the time as a key issue, whether the question would be to account for real-life farm operations or to consider their future sustainable development.

Many property rights and risk management research projects are undertaken to identify and support reforms of property institutions and land policies to achieve desirable pathways and mitigate negative impacts of undesirable pathways. These researchs emphasize the operation and organization of traditional management systems that have ensured a level of equilibrium over many centuries by controlling the access to rangeland and regulating social conflicts (Bourbouze & Gibon, 1999; Chaherli et al., 1997). There is a new appreciation of the way that pastoral systems cope with variability and change with property rights structure, beyond the classic categories of private, common, state or open access rights (Jabbar et al., 2000). The sustainable use of grazing lands depends also on the technical and economic balance of livestock systems which use the pasture resource (Gibon et al, 1999) and this emphasizes integrative and interdisciplinary research projects at the farm and community/regional levels to assess the ecological and social sustainability of livestock husbandry and grazing systems (Beranger et al., 1998).

Participatory approaches at the community/village level also constitute relevant research methods to identify and develop appropriated technologies. The "community approach" in "The Mashreq & Maghreb Project" (ICARDA) enhances participation of a wide range of stakeholders in the generation and adoption of appropriated technologies and accompanying policy and institutional measures. In this approach, community participatory mapping, in which the community members draws their territory and resources, allows the community to express their own perception of their -environment and land use (Bounejmate, El Mourid, 2001).

5) Farming systems observed on real farms are instantaneous measures of the very real and permanent changes in systems, adapting to changes in society and the environment. In Sub Saharan Africa, as in North Africa, the rangelands are under increasing pressure as human population growth results in ever more people depending on the harsh environment. This pressure is imposing considerable stress on the traditional land management practices, with sometimes violent conflicts between competing social communities. These events induce social changes arid may reduce incentives for prudent management by farmers and herders. Herd management is also sensitive to changes in risk and economic parameters such as price and marginal cost, which are both dependent on market and institutional environment. In these contexts, attention has to be paid to develop new opportunities at fhe farm and community level as new arrangements to enhance these opportunities.

Conclusion

In harsh environment, the traditional herd management appears to be essentially based on a closed and fitted management of vegetation resources and on the compromise between resource availability and adaptability of the herd to poor diets. This adaptation is done through two main factors: 1) mobility and migration; 2) the diversification of livestock species and breeds: by keeping more than one species of livestock, agro pastoralist are able to generate a wider variety of livestock products, harvest more of the available forage, use different environmental niches, generate livestock output in different seasons. This adaptation livestock-resource availability is also based on a confidence of the natural adaptation of the animal. This confidence is possible by the development by both the farmer and the animal of specialized knowledge about the environment (relief, topography, soil) and physiological and immunological adaptation to challenges. This social and cultural knowledge is a key factor of the sustainability of these systems and induces (the fundament of) a social and cultural identity of these farmers.

In many occasions careless application of innovation has led to hampering of the flexibility of traditional systems, the source of their regularity of herd production despite climatic uncertainly. A research effort to bridge the gap between the empirical knowledge of the management practices of traditional farmers in harsh environments and scientific knowledge will be necessary. The search for innovation for traditional livestock systems from a better understanding of lifetime based management practice appears to be as yet too limited, despite many valuable advances about animal body reserves, ewe lamb development and lifetime performance (Gunn, 1977, 1983; Vallerand, 1979).

Despite the appearance that impact of adverse climatic conditions on livestock production is the major common concern in the management practices of livestock farmers in harsh environments and should therefore be the priority for animal research, modelling of whole farm systems is considered to have greater priority. This integrative modelling approach calls for interdisciplinary research works, with the participation of the various stakeholders (farmers, NGO, extension service, administrators,...).

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PROCJENA STOČNIH I FARMSKIH SUSTAVA U GRUBIM UVJETIMA - PRISTUPI KOJE SU PRIHVATILI FARMERI KROZ ISKUSTVO UPRAVLJANJA

Sažetak

Znatan dio stočarske proizvodnje u svijetu odvija se u grubim uvjetima velikih agro - ekoloških ograničenja i nesigurnosti raspoloživih izvora vegetacije. Postoje velike razlike između sjevernih i južnih područja s obzirom na socio - ekonomske prilike, što uvjetuju odluke farmera kao i prioritete za razvoj stočarskog sektora. Ipak, procjene stvarnih poljoprivrednih sustava u različitim grubim uvjetima u oba područja pokazuju slične značajke poljoprivredne prakse iz čega se mogu izvuci neka temeljna načela za procjenu djelotvornosti LFS-a u održivom razvojnom djelokrugu. Ona su uglavnom povezana s upravljanjem rizikom na cijeloj farmi i na razinama stočarskog sustava promatranog kao integriran i složen sustav.

U ovom radu prikazani su i dani pregledi predavanja iz rada RiD-a u različitim grubim uvjetima kao sredstvo za utvrđivanje nekih općih razmatranja o običajima stočara. Stav farmera prema riziku, osobito u upravljanju biološkim resursima, čini se da je ključni čimbenik za razumijevanje djelotvornosti LFS-a i za procjenjivanje potencijalnih istraživanja u prilog održivom razvoju u LFS-u.

U grubim uvjetima tradicionalnog upravljanja stadom izgleda da se uglavnom temelji na zatvorenom i prilagođenom upravljanju vegetacijskim resursima i na kompromisu između dostupnih resursa i prilagodljivosti stada nedostatnoj hrani. Ovo se prilagođavanje obavi, putem dva glavna čimbenika: 1. pokretljivost i seoba, 2. raznolikost vrsta i pasmina stoke: držanjem više od jedne vrste stoke agro -stočari mogu proizvesti više raznih stočnih proizvoda, žeti više dostupnih krmiva, iskoristiti razne okolišne niše, proizvesti stočne proizvode u raznim sezonama. Ova prilagodba stoke dostupnosti resursa također se temelji na pouzdanju životinje u prirodnu

prilagodbu. Ovo je pouzdanje moguće ako se kod farmera i životinje razvije posebno poznavanje okoliša (reljef, topografija, tlo) i fiziološka i imunološka prilagodba izazovima. Socijalno i kulturno poznavanje je ključni čimbenik održivosti ovih sustava i potiče temelj socijalnog i kulturnog identiteta ovih farmera.

U mnogim slučajevima nepromišljena, primjena inovacija dovela je do poremećaja fleksibilnosti tradicionalnih sustava, izvora njihove redovitosti u proizvodnji stada usprkos klimatskoj nesigurnosti. Potrebno je istraživati da se premosti jaz između empiričkog znanja tradicionalnih farmera o upravljanju u grubim uvjetima i znanstvenog poznavanja. Istraživanja za inovacijama u tradicionalnim stočarskim sustavima za bolje razumijevanje običaja na osnovi životnog iskustva još su previše ograničena unatoč mnogim vrijednim uspjesima o tjelesnim rezervama životinja, razvoju ovca - janje i rezultatima u praksi.

Usprkos stavu da je utjecaj različitih klimatskih uvjeta na stočarsku proizvodnju glavna opća briga stočara u upravljanju u teškim uvjetima i morala bi, stoga, biti prioritetna u istraživanju životinja, oblikovanja sustava farma smatra se važnijim. Ovaj pristup sveukupnog oblikovanja zahtijeva interdisciplinarno istraživanje uz sudjelovanje raznih dioničara (farmera, NGO-a, podružnih službi, administratora ...)

Ključne riječi: grubi uvjeti, pristup farmskog sustava, upravljanje stadom, sustav domaćinstva, upravljanje rizikom, djelotvornost, održivost

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