Livestock future in North Africa. How can scientific knowledge progress, technical innovation implementation and local empiric norms and practices be improved?

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Livestock future in North Africa
How can scientific knowledge progress, technical innovation implementation and local empiric norms and practices be improved?

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Abstract. Two main findings can explain the gaps observed between the knowledge and practices of livestock actors in North Africa: (1) the breeders need time to experiment scientists proposals before either they adopt them, with or without changes and adaptation, or they forsake them; and (2) in live sciences and practices, since imponderable and unpredictable facts compel to look at scientific rules and reference models in perspective, it's difficult to implement, and, even more, to integrate into a system, accurate standardized procedures (especially in the dry and semi-arid areas). Taking in account these two aspects in consulting and training design and management of livestock systems requires: (1) that field managers are constantly careful to avoid ignoring (even, and often, unintentionally) the empiric knowledge based on a continuous survey of the whole system they are involved in, since (i) it is the main tool to achieve breeder's participation in an innovation trend, and (ii) even more, to avoid inciting (again, unintentionally) these breeders to drop out their own traditional and local practices; and (2) that fundamental researchers, by monitoring of the changes in their original findings throughout the experiments done by the users, improve and refine their knowledge of the progress, limits and enhancement achieved by every step that follows the formal transfer of a technology.

Keywords. Livestock – Innovation – Research findings – Applied science – Empiric knowledge – Empiric experiment – Monitoring.

L'avenir de l'élevage en Afrique du Nord – Bilan de la progression des savoirs scientifiques, la mise en œuvre des innovations techniques et les pratiques locales et réflexion sur les possibilités de les améliorer

Résumé. *Deux constats ressortent de l'analyse des décalages entre les savoirs et les pratiques des opérateurs de l'élevage dans les pays d'Afrique du Nord: (1) les éleveurs ont besoin pour expérimenter une proposition scientifique d'un temps au terme duquel soit ils l'adoptent telle quelle, ou en lui apportant des adaptations, soit ils la rejettent; et (2) dans les sciences et les pratiques du vivant, où l'impondérable et l'imprévisible obligent à relativiser les lois scientifiques et les modèles de référence, il est difficile de mettre en œuvre, et encore plus, d'intégrer dans un système des procédures normalisées (en particulier dans les zones arides et semi-arides). Pour donner leur place à ces deux faits dans la conception et la gestion de l'expertise et de la formation en élevage, il faut : (1) que les gestionnaires de terrain veillent à éviter d'ignorer (même sans en avoir l'intention, comme c'est souvent le cas), les savoirs empiriques fondés sur une observation continue de l'ensemble du système qu'ils guident, du moment (i) qu'ils constituent l'outil principal pour amener les éleveurs à participer à l'innovation, et (ii), plus encore, pour éviter d'inciter (ici aussi sans en avoir l'intention) ces éleveurs à abandonner leurs propres pratiques locales et traditionnelles; et (2) que les chercheurs des sciences fondamentales, en menant un suivi des transformations qui affectent leurs résultats d'origine au fur et à mesure des expérimentations des usagers, améliorent et affinent leur connaissance du progrès, des limites et des perfectionnements apportés par chaque étape qui suit le transfert formel d'une technique.*

Mots-clés. *Élevage – Innovation – Savoirs scientifiques – Sciences appliquées – Savoirs empiriques – Expérimentation – Suivi.*

I – Defining innovation and the chain of improvement projects

Since the subject of our meeting is getting our bearings about the technical and economic situation of Mediterranean livestock, the relation between theoretical or cultural and practical or material innovations has to be addressed more in terms of the chain of change in animal and animal market management than in terms of epistemology.

Concerning production system development, factual innovation is intended as a change, as well as a new tool, or technology, or practice, or behavior, introduced in a system, or in a way of life, to achieve this change. Change can be based either on empirical or on scientific findings. In fact, in this field, most innovations are generated more as part of improvement projects than by independent inventions.

The reliability of the chain of an improvement project can be assessed by addressing the project not according to its objectives, but taking in account its efficiency and the sustainability of its actions.

1. Research, project design, and target-people, roles and behaviors

When we talk about scientific and technologic progress, the word “innovation” has two meanings.

On one hand, it refers to a scientific discovery, a new fundamental research finding or the invention of a technology. This research is done in labs, controlling as much as possible all the items involved, analyzing samples and operating by simulations.

On the other hand, it means both a change and a new tool, a new technology, a new practice, or a new behavior, introduced in a production or a consumption system, or in a way of life to achieve this change. Thus, the transfer of the results obtained by the research must be understood in two ways. For the finders, it’s a process of transmitting, widening, spreading the knowledge. However, as far as the categories targeted by these inventions, (producers and consumers) are concerned, the main method to access the innovation is to remain well informed, up to date, and able to catch the information, by constantly following up the evolution of ideas, experimentations, experiences, and products.

In the innovation process, the fundamental findings consist in understanding the mechanisms and dynamics of the systems, stressing the role of each of their components, so they are the reference data of the technologic knowledge and findings. Those technology findings themselves, used when targeting improvement projects (in various fields) are transformed and adapted toward different situations before they are passed on to the target populations.

A revue of the chain of the improvement projects not based on their objectives, but taking into account their efficiency and the durability of their inputs, gives us the best opportunity to assess their reliability.

2. The chain of the improvement project

The improvement programs are achieved in a three or four stage sequence involving three actors’ categories.

A. First stage – Intuition and projects

A new idea, or level of knowledge, or technology, can either spring, arise spontaneously, accidentally, from an intuition, or be planned in a project of changes aiming at improvements. In the case of projected innovations, the research is initiated after an item of a system is defined as a constraint by the decision-making community and after the project of resolving it is planned.

B. Second stage – Labs and simulations

The whole system is then supported by fundamental research. The concern of each scientist team is therefore solely focused on a subsystem or on a single component of the system (that is actually itself a subsystem according to scientific values norms), whatever may be its role in the whole system mechanisms, considering the others as secondary objects, since they are seen as impacting the purpose of the study, whether they are major or minor in the whole dynamics and in the actors' concerns and strategies.

At this stage, the investigations and experimentations can succeed in theorized findings related to the mechanisms of the studied system or segment of system. Yet they are absolutely right only for the item considered and its bounds inside a given system in the research conditions, they are accurate and reliable in the state of the scientific knowledge and theories, whatever the specific conditions of each case. One can consider this step as a definitely successful one.

C. Third stage – Models, procedures, projects

The third step is engineering. Applied researchers are in charge of designing innovations based on the fundamental science findings and on diagnosis of the systems they are mandated to improve, especially from empiric knowledge and local practices. They start by elaborating a framework and referential toolboxes of norms, rules, models, schemes, and procedures, in the biologic, technical, economic, social, and institutional fields. They use them to design and plan up projects and programs.

D. Fourth stage - Spreading and extension

The last stage of an innovation project deals with the new knowledge, tool and practices spreading out.

The project team has then to convey their requirements to the actors in the systems, sectors and activities that they are asked to improve. This moment is assumed as the last of the whole intervention, the technology transfer and people empowerment operation. And the agency operators' tasks are usually seen in terms of target public acceptability, or ability to adopt the changes. And the methodological tools assumed as required are communication, persuasion, and extension ones.

It's important here to highlight the difference between the industrial items and the organic items. When you make an innovation by introducing industrial products and equipments, the factors that are to be taken in account are essentially prices, purchasing power standards, the terms and conditions of supply and maintenance, and the skills required from the workers in the industry.

In the case of production and consumption based on living organisms, whether they are vegetal or animal, one has to add to those factors the uncertainty of the prevision and the impossibility of mastering the environmental, physiologic and genetic dynamics

II – Innovation and North Africa livestock systems

The case of North Africa livestock gives us an opportunity to ask, if not to answer, how knowledge, standards and practices of (i) fundamental research, (ii) applied science and (iii) empirical strategies are reliable regarding the life and social sciences, and how each of these three approaches contributes to the design and management of sheep and goat system evolution in drylands.

Based on the relationship between innovation and growth, success, failures, continuity, breaks, changes, the point we have to address is, if an innovation is a progress factor whatever the case may be, under what conditions can it be profitable, or risky, or even dangerous.

1. The evolution of innovation in livestock in North Africa – All purpose and intense findings, moderate changes

A. A chronology of innovation initiatives – The 20th century acceleration

Beginning with the end of the story, that is today, gives us an opportunity to highlight the role of innovations in livestock systems. The last major innovation is the concern for environmental dynamics. This new spirit consists in a revolution in the whole approach of management behaviors. Thus, since it requires new technical, technological, and economic principles, it is becoming the major background for the general framework and orientations of the current research, development design and user practices and strategies.

Going back to the past, until the second half of the 19th century, genetic change in livestock has been continuous for nearly 10,000 years, since herds and traders mobility across the whole Saharan area and its margins has always encouraged crossbreeding. Local and transregional empiric selection, based on resilience, helped in strengthening animal hardiness even though it was impossible to face losses through drought periods.

In the 1850s, and until the 1950s, sheep and carcasses were exported to France. Thus, it's with an economic innovation, launched by European dealers, that started to change selection criteria, with governmental and associative departments setting performance and morphology-based norms of meat and wool eligibility and quality.

Before the 1930s, the concern for performance improvement gave way, in the three central countries, to systematic breed identification and certification and crossbreeding inside North African and between North Africa and European breeds. The criteria remained empiric, basing on phenotypes and performances.

From the 1970s, decision makers and research teams seek productivity increase and at the same time have a new concern for environmental conservation. In the 21th century, they still intensify at the same time breed conservation or valorization and crossbreeding inside each country or across the whole area. But these actions remain exploratory, since breed identification is still based more on phenotypic than on genetic features.

It's also in the first decades of the 20th century that the research in epidemiology and prophylaxis started. It had first to do with horse and cattle, due to their crucial role in the colonial military operations and in agriculture, as draft animals. At the time, sheep and goat were assumed as having to keep being raised on grazing lands, in a hardy system that could guarantee them good health conditions (Velu, 1928). By that time, as follow up and research progressed, small ruminant diseases and prophylactic or curative medicines were discovered. But until the 2000s, research was mostly interested in sheep. With the improvement of health organization, the concern focuses on pandemic watch and eradication.

As for feeding and watering management, until the 1960s, sheep and goat continued to be managed in pastoralist systems, and both fundamental and applied researchers did not recommend alternative methods. The decisive change consisted on adding supplementation feeds to animal diet. Launched by governments, it started in the 1960s and was generalized in the whole sub-region by the 1970s. The initiative aimed a double objective: (i) strengthen the animal resilience in uncertain conditions (ii) increase their productivity and meat and dairy production, in order to achieve sustainable human food self-sufficiency. It was decided in a global context of high level in grain production and stocks and good conditions in trade chains. In the 1980s, ley farming cultural systems were designed with the double objective of crop culture and livestock intensification. As for watering, on the one hand, veterinarians carry on researches in hydric stress physiology; on the other hand, fitting out watering points with motor pumps and digging new ones became a major item of the improvement policies achieved by most governmental and intergovernmental departments.

Motor tools use in livestock started relatively late, around the 1970s. Trucks were introduced to transport feed, animal, and then water. Settling motor pumps on watering points began to be generalized in the 1960s.

Range management and range improvement interventions have been going on for nearly a century. They started in the late 1930s and in the 1940s, when CRS and DRS offices and pastoral seed and tree nurseries where created by technical governmental departments, and, also, by private farmers. Governmental range development studies, projects, departments (Haut Commissariat de la steppe in Algeria, Project teams in Morocco, Offices régionaux in Tunisia, Code pastoral et Charte pastorale in Mauritania) were launched by the 1950s, with an intensification in the 1990s and 2000s, and more or less large lands were enclosed, as units of experimental or production improvement aiming good animal/resource balance rate implementation. There were seeded and planted pastoral species, organized rest rotation grazing and fencing plans.

A policy promoting livestock as a tool towards poverty alleviation and women emancipation was launched around 1965, then strengthened and developed in the 1980s. It concerns mostly goat, rabbit, bees, and small home flocks.

The commercialization of animal products is considered by researchers and governmental services from two points of view. Since the 1960s, the major goal is to increase producer profits and to lower detail prices by reducing the intervention of commercial intermediaries. The last innovation in the field, designed in the 2000s as matching with environmental concerns, defines livestock performance based less on animal management and features than on the attitudes of the consumers. Its major tool is to add value by labels, using often cultural and advertising means more than technical processes. Its spirit is reflected in the theme addressed in a meeting organized by the EU on 15 may 2013 in Brussels “Protecting value by marketing tradition and origin” (and it makes more sense when expressed in French “Protéger la valeur en commercialisant la tradition et l’origine”).

In the 1990, policymakers opted for an approach involving target people in the process of projects and innovation, from the diagnosis until the implementation. The principle of this change was to replace top-down approaches with consultation.

B. The institutional framework of innovation – Mostly government initiatives and incentives

Governments are responsible for most of the innovations dealing with livestock and its resources, except for motor tools. They make decisions, plan, finance, and control the research as well as its implementation, stressing on arrangements with intergovernmental and nongovernmental donors and borrowers and on extension and incentive operations. The incentives consist generally in subsidies. Governmental policymakers coordinate most fundamental and applied researches carried out by governmental or private departments, and since the end of the 1980s, require them to involve professional operators and consumers in the development and achievement of their projects. Concerning the organization of prophylaxis systems, arrangements with private veterinaries have been experimented, but they are scarcely success stories.

C. The difficult linkage between fundamental research and engineering in innovation management – A synthetic assessment

In short, the transfer from fundamental toward applied research is uneven as far as the different fields of livestock activities are concerned. A good coherence is achieved for motor tools and health (except for some difficulties in the organization of vaccination campaigns). Unless animal health is endangered by the contradiction between the legal dispositions of the North Africa subregion countries that forbid urban home livestock, though the small home livestock systems are

increasing in the whole area. Selection, reproduction and crossbreeding are hardly on their way to go beyond the exploratory stage. As for feeding and diets, a gap is obvious between the research in physiology focused on hardiness and resilience and applied initiatives based on productivity increase aims. The knowledge of the physiologic features of water needs and water stress is steadily developing. And since feed supplementation increase the need of water, livestock management is designed as including necessarily high standards of watering. But the debate about the research on the location of watering supply and its implementation is still open. While the designers have not yet defined a position on the impact of watering points on the range lands, nearly each government department and non-governmental-organization develop its web, and two or more wells can be fit out in the same place. Regarding range management, the new technologies, like remote sensing, vegetation nursery intensification, and ecosystem protection have a poor efficiency, since both research and engineering are constrained by the impossibility to foresee and forecast in the long term climate, water circulation, and vegetation dynamics as well as by the impact of long drought periods. While research and knowledge on marketing chains and marketing impact on the systems remain less advanced, voluntarist alternatives based on producer organization, cooperative models and some segments of the marketing chain suppression are recommended and widespread. The implementation of the participatory approach is difficult as long as the antagonisms between the aims of different stakeholders, especially between the long term, general and national goals of the designers and short term, individual, local interests is not well-mastered. Poverty alleviation and concerns for environment are two new tasks added to the designers' and managers of projects' responsibilities. Since the other objectives are the increase of the productivity and the conservation of the resources, and are themselves antagonist, it is obvious that these two increase the difficulty to conciliate the economic, technical, social and ethical objectives.

D. Ways and shapes of innovation transfer among the public – Strategies and negotiation

The measures and actions decided and set by the designers and managers of improvement projects are diversely respected by the users.

Herders and breeders criteria of animal selection are mostly physiognomic or economic (e.g. Sardi, that is taller than the other Moroccan breeds, is preferred for sacrificial ceremonies, ouled Djellal whom weight increase is fast, is praised in Algeria and eastern Morocco, the circulation of animals through boundaries is boosted by differential prices and government subsidies). Moreover, the producers use various empiric techniques of reproduction and selection, each of them fitting with a specific objective. They generally avoid a too strong consanguinity. When they look for good hardiness, they eliminate the weakest individuals, identified based on physiognomic features, by sales or by castration. They can also look for professional or social relations in other groups well known for the good quality of their livestock. Individual crossbreeding is implemented to achieve commercial objectives. In order to address the demand of the butchers and of direct consumers who buy animals for ceremonies, they keep in their flocks some individuals of different breeds and cross them, mostly based on phenotypic features. A tall stature, some colors of the fleece, or of the face, are preferred for sacrifices and feasts, fat, or thin and young, even weak are demanded by the butchers according to the purchasing power of their customers. The third kind of selection, controlled by researchers, using certified pure breeds, based on the conservation of the best individuals, and on the creation of ram nurseries among the livestock units, transferred and monitored by extension managers, is mostly practiced in Morocco by large flock owners belonging to professional associations. Anyway, their objectives are hardly the ones that have been defined by researchers. They are attracted by opportunities of financial or political benefits, like the market for Sicilo-Sarde ewe cheese, in northern Tunisia, or of Alpine goat cheese in some places, or an origin label on a breed meat (Noire de Thibar in Tunisia) or

the participation at innovations, or the subsidies linked to the obligation to keep in the flocks ewes of a peculiar breed, as Demman or Bni Guil in Morocco. But they manage their units in a pragmatic way, managing both a flock following strictly the recommended methods and another ruled by the market chain necessities. And actually the market demand is not limited to products having the quality criteria designed by nutritionists and labeling offices. Producers and dealers look for a large range of qualities in order to be in touch with the largest range of customers. In this spirit, health prophylaxis and care are unevenly implemented, according to how long the animals stay in a flock and to the price that can be expected in the market.

Feed supplementation has been adopted very soon after the initial operation of extension so that ewes would be forced to accept it. Subsidies and drought periods have helped to convince the herders. After a stage of experimentation in animal feeding, producers know how to fix adjustments in the ration that suits animal needs (especially sheep), local seasonal dynamics and year availability of pastures, and the ratio feed price/money resources.

In the different climatic areas, the herders organize the timing of watering according to the ratio green/dry forage and the availability of natural pools inside the pastures.

The fact that the principle of synchronization of lambing and resource dynamic has never been generalized among breeders can be linked to (i) the uneven rhythm of the resource dynamics that compel to develop opportunist strategies based on risk management (ii) the annual variability of the date where animal are mostly sacrificed (iii) the market demand and budget necessity all along the year.

Though transportation management varies in the different countries, the innovations in this sector are developed in social and economic webs and strategies more than for technical objectives, except for water supply. Trucks can be held either by specialized professionals or by livestock owners who use them for their own herds and to provide lucrative services, following the principle of never returning empty or underloaded.

Though governments continue to support the prophylaxis programs and campaigns, the producers implement them unevenly. Vaccination as been adopted by the herders one century after it had been launched, but more or less regularly depending on the time they assume it takes to maintain a flock before they sell it. Other prophylaxis measures are poorly applied. For example, vets' and herders' opinion and practices in prevention of parasitic deceases is debated. While, based on scientific experimentations, researchers maintain that pool waters (ghdir) endanger the animals since they are sources of strongylosis, shepherds water their flocks in those ghdir at the beginning of springtime arguing that this practice protects them against parasites (perhaps as a vaccination?).

The measures and actions decided and set by the designers and managers of improvement projects in range management areas are diversely respected by the users. They can either ignore them or include them in their strategies. Subsidies for breed conservation or feed as counterpart for pasture enclosure are often managed by the target people in ways that are considered by their designers as misappropriations and unfair practices and by the populations as arrangements and adjustments. For example, fences and grass rehabilitation plots are generally overused during the periods of open access and illegally grazed when shut. Actually, the contradiction deals with the difference between grazing plans based on even seasonal models and strategies of taking the best of opportunities during the short wet periods in order to strengthen animal so they can resist to the long dry periods.

The institutional changes that had been decided and advocated by governments are unevenly implemented by the herders and breeders of the five North Africa countries. The aids afforded to livestock are used to reinforce fortunes or to create emergent business. Nevertheless, whatever the kind of organization – association, cooperative, professional group – the relation between owners and shepherds keeps pursuing the same traditional hierarchy.

The pragmatic and dynamic conception of land use and land rights developed by the herders keeps being in conflict with the laws and measures designed by the governments (or is it the other way around, the legislation that is not compatible with the uses?). Nevertheless, the regular law system can be used to consolidate local strategies of resource use.

Livestock operators did not change significantly their marketing practices. Traders keep having a role of intermediaries all along the chain, between producers and consumers.

Participatory approaches are interesting essentially for the herders who have the capability to seize in them opportunities of emergence and capitalization. The lower class ones, small breeders or shepherds, benefit from this kind of involvement in the framework of uneven power and production relations with the big owners, that can be assumed as solidarity systems based on uneven economic structures.

Generally speaking, small ruminant systems have not been changed significantly by the numerous and important findings that occurred throughout the last century. New technologies in livestock or other activities development are very often used by people during the period designed by decision makers to launch innovations. Nowadays, program managers are used to see target people give up the new practices they had accepted, at the end of the stage of financial support, when, as they say, “the project is over”. So, producers have been less inclined to convert their practices, and more inclined to include into their own strategies, as tools of negotiation, the new approaches, initiatives and subsidies used by governments as incentive to enforce the science and engineering innovations.

E. The technical results of innovations on livestock – Little technical changes

First, it should be reminded that the two significant innovations related to livestock through the 20th and beginning of 21th century deal with cattle and with environment. On one hand, slaughtering cattle and dairy cow systems keep being intensified, while small ruminants are still mostly managed on range lands. On the other hand, the more revolutionary new change is the concern for environment conservation and rehabilitation.

However, technical changes have involved sheep and goat systems. The more obvious result of innovation policies in this field is the stabilization and growth of herd size that had been generated by the combination of health improvement, feed supplementation supply and need of goods easy to mobilize in a context of opportunities for money capitalization and circulation.

Together with genetic (though it is yet exploratory) and health improvement, feed supplementation has succeeded in improving animal conformation. Thus, as far as economic management is concerned, this change in physiology and diet towards intensification has increased the cost of livestock management and integrated pastoralists in the market chain. In principle, since feed expenses needed by taller animals are covered by selling animals, it does not so much endanger pastures by overgrazing. But even though, today, producers are coming back to rational standards, it creates the dilemma of either increasing high cost fodder crop production in uncertain conditions, or importing very expensive feeds.

An unexpected result of range management and environment conservation programs is the individualization of land, resource and tools use and property. Combined with motor progress, they had also succeeded in widening the mobility of the flocks, an innovation that is sometimes seen as a mean to decrease the pressure on grazing lands, and sometimes addressed as a factor of risk, since it causes an additional use in lands still used by other herders. The most important takeover of projects objectives is the valorization of the resources, especially of land, not as pastures but as a source of subsidies, since it is assumed that they are taken off from herders when

enclosed for grass protection or for large power ("conventional" fuel and gas power and "non conventional" sun and wind power) and mining projects. We can say that land value has been affected less by range management than by other activities innovation, as agriculture expansion, irrigation widening, or underground resource exploitation.

Considering the high cost needed to achieve the good and sustainable results necessary to justify the cost of the intervention for the governments, a contradiction ought to be stressed in the programs launched to improve poor women status through their integration in the market chain, granting them goats or rabbits. Let us quote here Luginbuhl and Poore's (1998) technical lecture: "Because of their unique physiology, meat goats do not fatten like cattle or sheep do, and rates of weight gain are smaller. Therefore, profitable meat goat production can only be achieved by optimizing the use of high quality forage and browse and the strategic use of expensive concentrate feeds".

Marketing innovations are still exploratory. However, the successful experiments are located in places where an initiative addresses a local demand, as for dairy camels in Nouakchott suburbs, cheese goats in Chefchaouen (Morocco), and, more importantly, Sicilo-Sarde ewes for various traditional and new cheese brands, in North Eastern Tunisia (with the success story of Numidia cheese, created in the 1970s in a cooperation program with Roquefort). When the projects deal with meat, especially pastoralist meat, the gap between weight and organic forage recommended by the contractual specification, the cost of labeling and packaging operations, the tradition of local taste preference and the competition and fashion turnover reduce the market of products like Noire de Thibar mutton (Tunisia), Bni Guil sheep, or Essaouira, or Talsint kids (Plan Maroc Vert, 2007).

In short, among herders and breeders, the same social and economic system goes on and is reproduced with modernized technical and institutional tools. While experts assume that most projects end up failing, it happens that the actual objectives of the decision makers and other operators are different from the one exposed in their terms of reference. In fact, they can use technical formulations and develop new findings to achieve strategic designs targeting either changes in local political and socio-economical situations or their consolidation. So, technical and institutional innovations have favored at the same time donors loans to the governments, speculation on land, animals and settings, policies meant for stop the increasing political and economic power of some local businessmen and families by giving other operators opportunities to emerge. The major fields of innovation are (i) the health and management factors succeeding in livestock stabilization, (ii) statistical monitoring and sectorial development indicators (for example the ones that take into account the shepherds as independent poor whose percentage rate justifies project fees, and not as operators of the system depending on the owners, who happen thus to be the best, if not the sole, partners in the consultations aiming to improve the system) and (iii) population organization (that can help to consolidate the social system updating its formal mechanisms).

It can be added that while the traditional livestock systems support the poor's livelihood in the whole sub-region, the interest for livestock projects and the innovations they are related with is an indicator of the relative importance of livestock opportunities among economic activities in each country.

But we cannot conclude that the gaps in the transmission of new technologies are originated by producers' misunderstanding of the right practices and low intellectual level, nor that research and engineering have been completely wrong in their findings because they did not understand the extensive livestock systems. It is possible to think that the innovations have not yet been experimented enough to conclude that they definitely failed.

2. A typology of innovations in livestock – Reliable, uncertain and progressive findings and proposals

After this retrospective of innovations in the livestock industry, and considering them based neither on the field they are involved in, not on their objectives, but on case study results, five types of changes can be defined, according to their reliability, feasibility, and sustainability.

A. The innovations in fundamental research are reliable

The approach and methods of fundamental research certainly guarantees the reliability of its findings in the temporal and spatial conditions specified by the protocol. Thus, before they base a practical innovation project on them, engineering teams must have a good knowledge of each situation they have to deal with, in order (i) to assess intervention relevance and (ii) to define the implementation procedures and modalities fitted with the situation. (Ex 1: goat milk taste doesn't depend on the grass species they graze but on physiological and genetic features of the goat specie. The question is here to decide whether it is appropriate to base a marketing operation for goat cheese on the vegetal units it comes from. Ex 2: the necessity of enterotoxaemia vaccination depends on the regularity of animal diet. The question is to decide whether it is wise to do the prophylactic choice of a regular diet or of regular vaccination, knowing that considering the resource scarcity and climate conditions of dry and semi-arid areas, plus the goat meat market uncertainty, herders must choose either to take in account seasonal mortality as a natural fact, or to include in their management large feed costs, or to stabilize their flock size by a regular vaccination.)

B. Sectorial practical changes are voluntarist

The managers of an improvement project (whether it is meant to increase the productivity or to preserve the environment), can decide that a change in one of the practices of livestock management will be profitable to the whole system. But since the approach of applied research in livestock science is mostly based on an average model of animal, built as a medium term between the features of various types and systems, the innovations can hardly fit each particular current sheep and goats system. For example, (i) some feed supplementation rations prescribed in sheep management improvement are too abundant compared with sheep physiology, (ii) the results of incentives to increase meat production are not guaranteed in a context of low purchase power, (iii) the approach and measures of rangeland-police aiming to decrease animal charge on the grazing lands can be impossible to implement in livestock systems developed in uncertain climatic situations, or (iv) pasture vegetation improvement is not relevant in Saharan short lived grasslands.

C. Changes in the organic material are uncertain

Another kind of change is made in animal or vegetal material (or both) in order to improve it based on identifying phenotypic or genetic features that are ranked by operators (breeders, meat traders, governmental decision makers, environmentalists) according to their targets. Except in cases when the changes involve genetic lab manipulations, they can only be empirical and exploratory, thus uncertain. (For example, cross-breeding of different sheep breeds in an approach of empiric experimentation, or seeding local vegetal species in dry areas, where climate uncertainty and unpredictability put a heavy constraint on any regeneration).

D. Empiric continuous innovation is imperceptible

Whereas the local and empirical changes in agriculture are easily detectable, in livestock, especially in pastoralism, it is difficult to assess the process and the findings of the innovation done by the users, since they result from daily imperceptible individual adjustments based on their own knowledge capitalization of livestock conditions progresses, and they are transferred through consultation between the herders.

E. Innovations by changing the use of a tool are clever or disastrous

Some innovations are done by users who divert a tool from its original function. These initiatives can lead to either technical improvements or the deterioration of the whole system or of a segment of the system. One example of an improvement are the women of the Tiznit area (Morocco) who replaced the traditional goat skin churn by small handle washing machines; a negative example is the one in South Morocco urban small holder systems, where goats are fed with book or newspaper sheets, or with dry bread if flour is subsidised (they buy fresh bread, and they dry it then they dip it in water often leaving it until it molds).

F. Changes generated by pure adoption of an innovation are more strategic than technical

When a user makes an innovation by adopting a technology, or a tool, without changing anything in it, the proposal finder has to ask if the choice is done for a technical purpose or with an economic and political intention. In fact, it's possible either that this introduction improves the system, or that it is abandoned when the educational, aid and subsidy program is finished, or that it had technical meaning and effect since its introduction. (Ex: in projects like the Algerian program of dryland range improvement, where arrangements were made to plant forage trees in common right lands, so the herders who accepted the operation changed them in individual use areas, and, after a time, in private property right; acceptation of dairy goats in home livestock systems without changing the management practices; labeling breeds and no products, as Noire de Thibar, or Doghma, besides the official breed inscription; pastoralist Code and Charter elaborated by policymakers and herders after a consultation are not implemented, but anyone is interested in explaining why).

G. Changes done by adopting an innovation after a more or less long experimentation period seem suitable

Some innovations are adopted by each users' category, even by each individual, throughout a more or less long time of testing and self experimentation. We can think that this empiric professional approach succeeds in a good mastering of the system mechanisms (ex: in all North African countries, the breeders have integrated the prophylaxis policy after a century of prudent observations, and according to their economic strategies; feed type and ration for supplementation have been studied and adjusted by the herders from the innovation launched by governments, from 1962 until the end of the 1990s).

III – The facts and the alternative approach

The gaps observed in livestock management between the standards of scientific knowledge, the reliability of the technologies implemented based on engineer sciences, and producer practices can be assumed as generated by the fact that the innovation chain is not completed and achieved. It is planned in three stages, as if the improvement actions were pure lab experimentation, so that "Once a plan is developed and the identified practices are being applied the resource needs to be monitored to see if the desired changes are occurring" (range management handbook, no reference, on the web), instead of including as a fourth stage the period of experimentation by the users.

When the incentives of a project designer are very attractive, like subsidies, the risk deals not only with a lack of acceptation, but also, on the opposite, with an acceptation leading to the loss of the ecosystem and economy balance.

The current approach, based on the assumption of an uneven capacity of understanding between scientists and target people, addresses the users with a psycho-sociological model. In this approach,

people go through a first stage of mistrust and cultural fear when they face new technologies and ideas. Actors just have to go through this period until time passes and the innovation is widespread through extension. It is then seen as usual and familiar and adopted. In the other hand, the technico-professionnal conception considers the introduction of an innovation as a consultation and negotiation between experts in an activity. The users, especially the producers, are here recognized as having skills, knowledge, and experience that give them the ability to experiment a new technology or tool. Therefore, the alternative to achieve an efficient consulting and educational project aiming at the improvement of livestock systems must involve field managers and researchers not as providers of right practices and producers as customers and pupils, but the three of them as experts carrying on a professional permanent consultation. It means that (i) applied researchers and program managers have to keep making sure to avoid to ignore (even, and often, unintentionally) the empiric knowledge of the herders, itself based on a continuous survey of the whole livestock system, since it is a major tool to achieve breeder's participation to an innovation trend, and even more, to avoid inciting (also unintentionally) these breeders to drop out their own traditional and local practices, (ii) fundamental researchers don't carry out assessments of the capability of the target people to understand and accept the innovations proposed by the project, but monitor the changes in their original findings throughout the experiments done by the users, improve their findings and refine their knowledge of the progress, limits and enhancement achieved by every step that follows the formal transfer of a technology.

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