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## Evolution of goat production systems in the Mediterranean basin: Between ecological intensification and ecologically intensive production systems

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## ABSTRACT

In Europe and in the Mediterranean basin, goats and especially dairy goats have a peculiar importance and their production systems have been deeply changed during the last 50 years. Although the goats are generally seen as environmental friendly, the goat sector is more and more questioned by the general environmental challenges faced by agriculture and livestock Production. Agro – ecology is the general movement and approach to study the application of ecological principles to the design of sustainable agro – food systems. The several forms of agro – ecology and their application in animal production are reviewed; the concepts of ecological intensification and ecologically bio diversity based animal production are mobilized to introduce the possible types of changes implemented in a diversity of situations. The integration of goat activities in agro – food industry and the social role of goats by small holders in rural areas are the two main drivers to understand what forms of agro – ecology to implement for sustainable goat systems in Europe and in the Mediterranean. After having underlined the importance of agro – ecological transition as a complex process involving environmental, technical, social and societal changes, several methodological approaches based on real situations are proposed to address this transition for goats.

The conclusions of this survey insist on the importance of the participatory approach to build collectively solutions adapted to each situation. Consequently, agro – ecology could be a good driver to impulse new dynamics in the goat sectors and especially in Europe and the Mediterranean area. Several pathways could be followed with a diversity of agro – ecological profiles to favor the sustainable development of goat systems.

### 1. Introduction

After World War II, agriculture and animal production have been dominated by one main model based on the intensive use of external inputs (Stassart et al., 2012). In the years 1980, the awareness of the negative effects of this production model on biodiversity, ecosystems and climate change has emerged, as well as on product quality, human health and the increasing scarcity of fossil resources, water and natural phosphate deposits (MAE, 2005; IAASTD, 2009; FAO, 2006; Rivera-Ferre et al., 2016; Batalla et al., 2015; Perez-Neira et al., 2012). Although often neglected, the negative effects of this model were not only environmental but also social and economic by considering a forced accumulation pattern, the deterioration of working conditions and the increase of disparities and structural weaknesses (Allaire, 1988; Mazoyer and Roudard, 1997). Recently, regarding animal production, ethical issues regarding animal welfare in this sector have been also more and more considered (Thoma et al., 2010; Entrup, 2014).

Consequently, several frameworks and concepts have been thought to strengthen the sustainability of agriculture and animal production (organic agriculture, integrated production, sustainable intensification, conservation agriculture, ecological intensification, agro – ecology, etc.).

In a fast changing world, most of institutions or initiatives address today global food security, equity, preservation of resources and climate changing mitigation as major issues for livestock. All the animal production sectors including goats have been questioned by environmental challenges (Steinfeld et al., 2006) and transitions toward more ecological production systems are required to re define their role in global food security. The evaluation of the environmental impacts of conventional models has promoted new ways of limiting such dominant production systems (Godfray et al., 2010) which are addressed by their ecological orientation. In this context, more than for any other livestock, goats have faced a strong paradox. Once apart from the dominant main stream of livestock, and less impacted by the dominant model and

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intensification, goats have a strong positive naturalist environmental friendly image although in many regions the production systems have been deeply modified; they have been intensified with increased performances and have included important technological innovations.

After considering the main concepts and theoretical approaches of agro – ecology, the objective of this article is to review beyond the usual mental models at what extent goat farming in the Mediterranean basin is now concerned by these agro – ecological issues and what ecological orientations and transitions should be required. A special focus is given to the economic, social, societal and environmental dimensions of goat farming, how they are identified in the farms, with what indicators and especially, for grazing and pastoral goats.

## 2. The several forms of agro – ecology

Agro – ecology is the application of ecological principles to the design and management of sustainable agro – systems; more largely, it considers all agricultural practices and biological interactions in an optimal use of the ecological possibilities offered by agro – systems and could mobilize several orientations.

Quoted for the first time by a Russian agronomist (Bensin, 1928) and initially developed for crops by several authors like Altieri (1983, 2002) or Gliessman (1997), the declination of the principles of agro – ecology for animal production has been very recent and has proposed new ways of producing to favor the integration of animals in one's agro – eco – system (Gliessman, 2006; Tichit and Dumont, 2016). The five steps of agro – ecology in agriculture and livestock systems are sum up on Table 1. The introduction of ecological innovations and approaches has to focus not only on environmental issues but also on their social and economical benefits (Horlings and Marsden, 2011). The nature of problems to solve will define the type of change to introduce. If the focus is to improve a single problem (for instance, decreasing environmental impact of a diet), the type of change needed would be only incremental; if it is to correct it, by mobilizing other resources without changing the strategic objective of the system (modifying the forage system by introducing pastures for instance), it would be a substitution change. For these two situations, the production systems would not have to be redesigned. But if the strategic objectives of the systems and their technical characteristics are modified, the changes lead to a socio – technical break, what would require transition pathways. Several types of transition pathways could be identified according to the importance of transformation, reconfiguration, technological substitution and de – alignment (or re – alignment) in the multilevel interactions of the actors (Geels and Schot, 2007). Two main concepts have been mobilized to characterize these changes in production systems, “ecological intensification” and “ecologically intensive bio – diversity based agriculture and animal production” in relation to the type of transition pathways. Agro – ecology can be seen simultaneously as a science, a movement and practices (David, 2009).

**Table 1**

The five steps of Agro – ecology (Gliessman, 1997, 2006) in agriculture and livestock systems.

Step 1 – Increase the efficiency of the inputs, reducing the costly rare and inputs and with environmental impact – <i>No system change.</i>
Step 2 – Substitution of inputs and conventional practices and production alternatives. Includes the organic movement and interactions with farmers to find alternatives – <i>No design changes</i>
Step 3 – Agro –ecosystems are re – designed on the base of new ecological processes – <i>new design.</i>
Step 4 – To reconnect the producer and the consumer in alternative networks of solidarity – <i>breaking</i>
Step 5 – To build a new global system of food based on equity, participation and justice not only to guarantee sustainability but also to restore and protect the planet – <i>breaking</i>

### 2.1. The ecological intensification (EI)

As defined by Hochman et al. (2013) EI advocates a paradigm change by promoting production systems based on the comprehension, the utilization and imitation of ecological processes implemented within agro – systems rather than on their artificialization and the utilization of chemical inputs (Griffon, 2006). But this EI has mainly an environmental objective and no special social focus. The EI of production oriented agriculture is based on an increasing resource use efficiency (fertilizers, pesticides and waters), recycling wastes and by – products, replacing chemic inputs by organic ones or developing precision agriculture technologies. For instance, this form could open the way to the generalized and presently questioned use of genetically modified organisms (Godfray et al., 2010). It is why we can consider that this form is the continuation of the productivist model of specialization which has dominated agriculture since the fifties. Its main objectives are both to raise production limits of agriculture and reduce its negative environmental effects. This efficiency/substitution form of modernization modifies incrementally practices in specialized production systems to comply with the environmental regulations without changing radically the paradigm of progress (Duru and Therond, 2015). Although widely questioned, the mental models of many actors including development project leaders are still driven by the idea that any technical progress would necessarily lead to social and economic improvements. EI is based on the improvement of the efficiency of the key resources in dominant regimes such as infrastructures, production norms and standards or their substitution by ecological technological solutions and innovations. EI would be presently dominant due to its ability to create technological, institutional and organizational “locks in” (Cowan and Gunby, 1996), this “lock in” being the consequence of the existing educational systems and dominantly used references which have formatted the minds of many actors who have difficulties to think differently.

### 2.2. The ecologically intensive bio – diversity based agriculture and livestock activities

The second form of change toward agro – ecology is oriented on bio – diversity and based on the eco-systemic services at field, farms and landscape levels. Its objective would be to reduce the human interventions and optimize the potentialities of eco – systems within local and regional systems. Griffon (2006) speaks paradoxically of ecologically intensive bio – diversity based agriculture, to optimize the ecological properties of the systems. Seen as social – ecological systems based on past and local experiences, bio – diversity based agriculture and livestock activities are complex adaptive systems encouraging experimentation, participation of stake holders, polycentric subsystems of governance and producing flexibility and responsiveness. This bio – diversity based agriculture introduces a more important paradigm shift in the vision of agriculture or animal production innovations and systems in their objectives and expected performances (Caron et al., 2014) but also in the management of the interactions between environment and production. This involves a deeper re – design of the existing systems and this agro – ecological transition requires a convergence of favorable conditions and opportunities with public policies ensuring these alternative models. A main issue is the articulation between bio – diversity based alternative models and dominant ones (Stassart et al., 2012). It seeks to develop diversity in species and genotypes to favor functional complementarities in resource use and biological regulations (for instance by the use of local animal breeds adapted to their environment). Bio-diversity based agriculture develops both marketed economic (food providing) and not marketed eco-system, positive or negative services (carbon storage, control of water cycles, landscape preservation...). It could also lead to changes and interactions between production practices and consumers behaviors. To develop it, innovation cannot be only technological and technical but must be also social,

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