ENVIRONMENT AND FOOD AND AGRICULTURAL SYSTEMS

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Summary

Agricultural systems have the primary function to produce food and renewable resource, but additionally their affects on the environmental resource water, soil and atmosphere are important. On the other hand, agro-ecosystems rely on the function of those resources. Apart from the relations on the basis of natural sciences, economic and social aspects are important. The diversity of agro-ecosystems is strongly affected by the human influence. It is important to note, that the effects are always positive and negative, however, it is almost impossible to design agro-ecosystems without any effect on the natural environment.

The different considerations on an ecosystem level underline the main function of an agro-ecosystem: Production of food and fiber using sunlight (energy) with as little impact on the environment as possible. The targets are not solely determined by the farmer, but society as a whole strongly affects agricultural systems.

1. General Background for Agro-Ecology

Since the very beginning of agriculture, mankind has dramatically affected natural processes of ecosystems and changed these processes according to his objectives. By doing that it was empirically realized which measures and interventions take into account the demands of nature and which on the other hand could also safeguard sufficient harvests for the food security needs of a particular population. From this interrelation lasting for centuries knowledge was gained and agricultural systems which

closely related to natural processes were established. A primary target was the replacement of nutrients previously taken away with the harvest. This is the reason, why the first developments of agriculture occurred on fertile inundation areas of rivers, the shifting-field cultivation and finally by three-crop rotation systems. Over time, those specific types of land use radically changed the characteristic of landscapes. This is especially visible in Alpine pastures, fertile plain landscapes, headland and intensive rice producing areas in Asia. This change also dramatically affected the natural flora and fauna of the particular regions.

1.1. The Field of Ecology

From the beginning of the establishment of ecology as a scientific discipline about the interactions of the organisms with their environments at the beginning of the 19th century man tried to understand and identify the scientific background of such interactions. This was an important progress following a mere description without understanding on the process level previously. Generally speaking, ecology is the science of all relations of an organism or a population with its biotic and/or abiotic environment.

To gain more insight into the interrelation of “actio” and “reactio” it is also the basis for a thorough understanding on the process level and a prerequisite to forecast responses of populations to the effect of disturbances like changes in temperature, water and nutrient supply, fire, food supply, competition, be it natural or by human interference. The complexity of nature makes it necessary, that different research approaches must be followed in the description and investigation of ecological facts. This is the reasons, why different approaches have been applied, which are called autecology (physiological ecology), demecology (population ecology) and synecology (community ecology).

Autecology focuses on a single species in its relation to a separate environmental factor (e.g. temperature effect on the development of an organism), whereas researches in the field of demecology tries to identify the dynamic processes of population growth within time and space, considering also the genetic background of a population. These processes of mass fluctuation are mostly driven by multivariate environmental factors. In contrast, synecology takes into account the complete biosphere, that is all interactions between populations (biocenosis) and biotop, of the entire ecosystem.

The scientific approach has thus become more and more comprehensive and computer aided models like decision support tools for knowledge generation and for result illustration has gained greater importance in recent years. Progress in the science of ecology has been most advanced in areas with relation to ecosystem preservation. The ability of the ecosystems for resilience, persistence and resistance against disturbances are in the focus of that type of research.

Resilience describes the buffer capacity of the system while resistance covers the durability and persistence of the ecosystem against disturbances. So the "balance" of the system is assessed in total. Also the question about the connection between biodiversity (as species number) and ecosystem stability leads into the same direction. Until now, this question is not sufficiently answered and different interpretations are given (see

Figure 1). The figure illustrates that the scientific opinions still differ about the correlation between species numbers in an ecosystem and existing ecosystem functions.

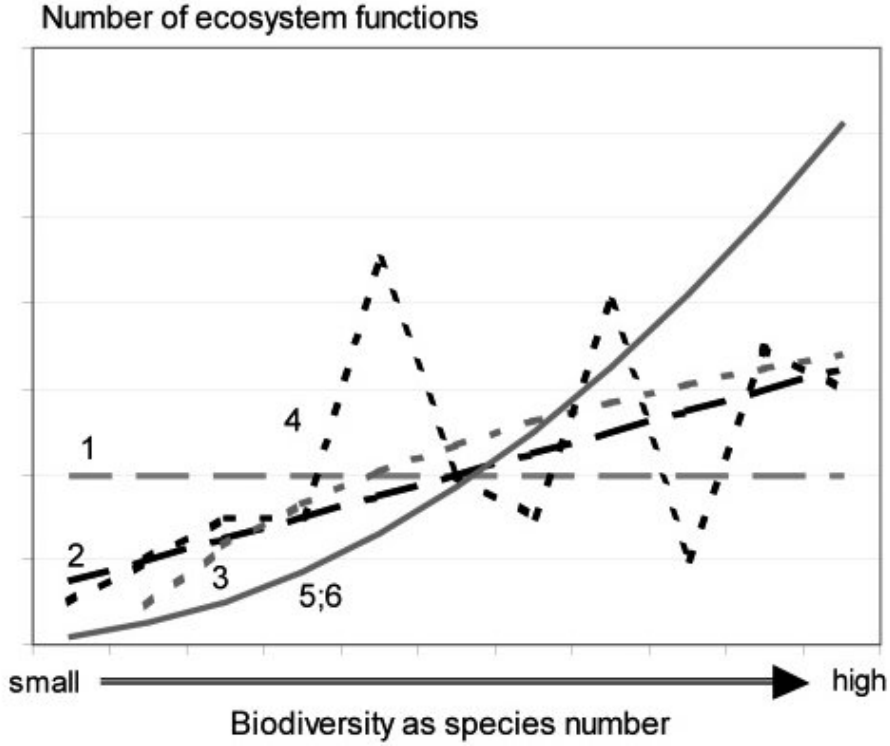

Figure 1: Schematic relation between biodiversity and ecosystem functions.

The different opinions cover a wider range from a total negation of any interaction between biodiversity and ecosystem functions one the one hand (hypothesis of neutrality, 1), to very strong interactions (3; 5 or 6). Other scientists' hypotheses that a relation exists, but cannot be used for forecast (4). This scientific discussion is extremely important because agreement exists that a higher number of system functions improve the resilience, persistence and resistance of the ecosystems and thus strengthens the ecosystem stability in total.

Beside this point, another aspect gets special significance in the discussion. It focuses on the interaction between the species number and ecosystem functions. With other words, if the number of species determines the ecosystem functions, the ecosystem functions affect the biodiversity of the ecosystem. This latter fact plays a significant role in the evaluation of agro-ecosystems.

1.2. Specifics of Agro-Ecology

The contents and approaches of agricultural ecological research do not show any principle differences in comparison with general researches in the field of ecology. All facts mentioned above are included but may differ slightly in the analysis of agro-ecosystems, given by different aims in the orientation of research. One example is the smaller importance of natural processes and its effects on the ecosystem in favor of

anthropogenic profiles of disturbances, which arise in a multiple way from agricultural land use and represent themselves in the particular condition of the agro-ecosystem or the environment. Therefore, a main aim of agro-ecological researches consists in evaluating the effects of land use systems on the site-specific productivity and environmental condition with regard to future developments. The term "environment" particularly includes the abiotic and the biotic environmental resources, i.e. the soil, water, atmosphere, biodiversity and the landscape in total to be protected.

Agro-ecological research is focused on the use of "ecosystem services" for agricultural production, which arises from the functional network between all elements and strata of an (agro-) ecosystem. The meaning of listed targets of agro-ecology gets more obvious if the special features and the functional background of agro-ecosystems are known and quantified.

Figure 2 shows important characteristics of (agro-) ecosystem as an overview illustrates the functional processes taking place in the system and highlights the main ecosystem strata. A decisive characteristic of the agro-ecosystem is its openness. This means that produced goods as harvests are taken from the system. This is biomass including organic substances, nutrients and of course energy incorporated in those products.

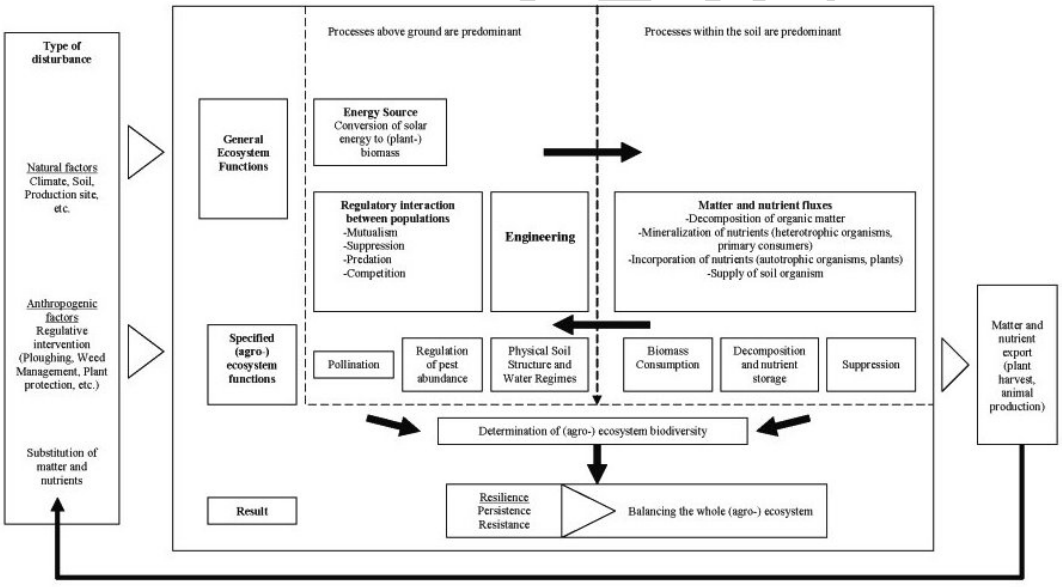

Figure 2. Characteristics of an agro-ecosystem

Durability and productivity of such an ecosystem is only maintained if a return of biomass and nutrients into the system is carried out. Otherwise the agro-ecosystems would be characterized by a depletion of nutrients, which consequently alter the ecosystem itself. It is therefore one of the most important tasks of a farmer and a decisive feature in the distinction of natural and agro- ecosystems to manage this matter cycle. This, obviously, does not happen in a natural ecosystem. It is thus assumed, that a conscious management of the process, which affect the different interactions between the various ecosystem strata, are largely known and understood. Additionally, this is the

reason why the soil plays such a special role as habitat and nutrient storage in agro-ecological research. To illustrate the significance of soil processes it is often declared as "the intestine of the plant".

Obviously all ecosystem functions occur in natural, semi-natural and agro-ecosystems, however, the specificity in agro-ecosystems is different, or the functions are modified in either direction due to anthropogenic influences. Another important fact included in Figure 2 shows the orientation and targets of agro-ecosystems. Natural or semi-natural ecosystems normally show durability according to the goals of nature preservation, i.e. they encompass a persistence and undisturbed development (succession). This is profoundly different in agro- ecosystems since annual agricultural interventions like soil tillage, harvest and all other husbandry operations change the undisturbed development. In contrast, the buffer capacity (resilience) to compensate natural, anthropogenic influences and disturbances have greater relevance in agro-ecosystems to prevent productivity losses and environmental harms.

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Biographical Sketch

Wolfgang Heyer studied agriculture from 1969 to 1972 at the Martin-Luther-University in Halle (Germany), with the specialization in plant protection, particularly in integrated pest management (IPM). In 1976, he received his PhD from same University. He wrote his thesis on ecological investigations of

the cereal leaf beetle in the central parts of Germany (life cycle, population dynamics, damage capacity). The results were used to create a monitoring system for the whole country, including computer based simulation models for cereal leaf beetle dynamics in winter wheat fields (PESTSIM OUL). This was followed by five years research work on pests in tropical bean stands in the Caribbean (computer aided pest prediction, damage thresholds, monitoring instructions). Recent work at Halle University is mainly concerned with studies on beneficial arthropods in agricultural land, with the aim of their possible protection and support for increasing their population. Additionally, these ecological results form a basis for evaluation of farming systems with special focus agro-ecological questions and biodiversity.