CONVERGENCIA
Revista de Ciencias Sociales

Agro-ecology and sustainability

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Abstract: The paper emphasizes the importance of agro-ecology in the search for sustainability of natural resources management in rural areas. It starts discussing the relevance of reaching balance between the natural and social systems. A holistic interpretation of natural and human systems through the concept of coevolution is proposed, as well as the incorporation of sociocultural and economic elements in the analysis of ecosystems, emphasizing the challenge of transition from the market value towards the ecological value and human wellbeing. In the second part of the study, a multidisciplinary approach for the management of agro-ecological systems is presented as a fundamental requirement for sustainability, stressing the importance of agro-ecology in the efforts for achieving development, productivity and social profit in the long term. The paper closes by discussing the challenge of agricultural research towards the study of complex interactions and transdisciplinariness; emphasizing the importance of institutions on researching and promoting the agro-ecological practice; and it concludes analyzing applications, limitations, potentials and perspectives of agro-ecology as an emergent discipline.
Key words: Agro-ecology, coevolution, complex systems, sustainability.
Resumen: Este artículo enfatiza la importancia de la agroecología en la búsqueda de la sustentabilidad en el manejo de recursos naturales en zonas rurales. Se inicia discutiendo la relevancia de lograr el equilibrio entre los sistemas natural y social para la sustentabilidad. Se propone la interpretación integral de los sistemas naturales y humanos a través del concepto de coevolución, así como la incorporación de elementos socioculturales y económicos en el análisis de ecosistemas, enfatizando el reto de la transición desde el valor del mercado hacia el valor ecológico y el bienestar humano. En la segunda parte del trabajo se presenta el carácter multidisciplinario del manejo del sistema agroecológico, como requisito primordial para su sustentabilidad, resaltando la importancia de la agroecología en los esfuerzos para lograr el desarrollo, la productividad y la utilidad social a largo plazo. El trabajo finaliza discutiendo el reto de la investigación agrícola hacia el estudio de las interacciones complejas y la transdiciplina, enfatizando la importancia de las instituciones en la investigación y promoción de la práctica agroecológica, para concluir analizando las aplicaciones, limitaciones, potencialidades y perspectivas de la agroecología como disciplina emergente.
Palabras clave: Agroecología, coevolución, sistemas complejos, sustentabilidad.

ISSN 1405-1435, UAEMex, num. 46, January-April 2008, pp 35-71

Introduction

In the sphere of the theory of development, in the last decade of the XX century, the concept of sustainable development appears, which incorporates the environmental character to the discussion with concepts on stability, resiliency[1] and adaptability, conjugating them with the economic approach based on productivity, efficiency and efficacy and the social discussion on equity. In this discussion the central value is inter-generational equity, which implies a legacy of social, economic and natural capitals from the present generation to those to come.

This primordial value's achievement requires the comprehension of the functioning of the natural systems from the environmental point of view, and their preservation from the socio-economic activity. The approach of the complex adaptational systems permits both the disciplinary analysis of the environmental, social and economic kind and the analysis' multidisciplinary integration.

On its own, the co-evolutive vision proposes that societies interact with their local environment, enriching or degrading it according to the knowledge and valuing the people have of it. At the time, the environment responds providing society with resources of high and low quality, according to the level of degradation it has undergone.

The co-evolutive vision can be approached from diverse scales. From a local approach, cultural plurality responds to the environmental diversity and vice versa. From a global approach, the prevailing and globalizing development model co-evolves altogether with the planet, the former seen as a large environmental system.

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[1] An agro-ecosystem is considered sustainable when it produces, in a steady state of equilibrium, a specific combination of goods and services, which meet a set of goals (productive), with no degradation of its base resources (steady). Its sustainability level will depend on its capacity to face (reliable) and rapidly recover from disturbances (resilient); as well as finding new alternative states of steady balance (adaptable); without compromising its productivity and reproducibility. Every activity must be based upon the organization of the people involved (self-management); avoiding as much as possible dependency on the outside (self-dependent) in the search for the most benefit for everyone and with the aim to achieve equity between its internal and external relations (equitable) (Masera *et al.*, 1999; Bell and Morse 2003; López-Ridaura, 2005).

At the local scale, the management societies have of their environments and natural resources depends on the activities and human values (according to the associational hedonistic psychology), which as socio-cultural elements are worth being defined and characterized, since the effect they cause determines the quality of the ecosystems and their capacity to provide material goods and environmental services to local society. In this sense, ecological value and human welfare become relevant.

A relevant form of intervention of societies into their local environments is that of the agricultural activity. A modality of the agricultural methods and techniques is ecological agriculture, based upon the agro-ecological theory. Our purpose in this work is to reinforce the proposal that the theory and practice of agro-ecology can contribute to improve the sustainability of the agricultural systems, both in their environmental (natural resources) and social (mainly rural producers) components.

The theory of agro-ecology incorporates into agriculture the already mentioned concepts of stability, resilience and adaptability, apart from those current on productivity, efficiency and efficacy in production. The objective is to improve welfare, quality of life, and equity among agriculturists.

The basic concepts analyzed in agro-ecological theory are: the agricultural performance of the strategy of development known as "Green Revolution" (based on modernization and adoption of technology); the autochthonous strategies applied on the traditional agricultural systems; the uses and destinations of agricultural production; and the environmental impacts derived from the diverse productive strategies.

In this analysis fundamental are the principles of places' specificity, multiple interactions, agro-biodiversity and poli-cultivations; as well as the approaches of analogy with natural ecosystems, multi-specification and facilitation; spatial and temporary diversification and integrating effects of the agro-ecological production techniques.

An essential principle discussed in this work is the redesign of agricultural systems, as starting point to achieve a structural transformation of the methods and techniques of production. It is also discussed the importance of the institutions in researching and promoting the practice of agro-ecology. The purpose in this point is to propitiate the reflection on

1the requirements to be met, if it is indeed sought to start such transition. In this sense the limitations, possibilities and perspectives of the theory and practice of agro-ecology are distinguished.

Our work closes with general reflections on what society must face in the search for sustainability, in a globalized world and overly economized, where uncertainty and rhetorical debate prevail, fed by seduction and massive simulation. We finish stating the need the scientists have to consider emergent realities and propitiate dialogue between diverse fields of knowledge in order to reach an integrated and multidisciplinary thought able to face them.

The importance of the equilibrium between the natural and social systems for sustainability: co-evolutive approach

Sustainability is a concept which summarizes the efforts to achieve development, productivity and social usefulness in the long term (Rigby and Cáceres, 2001). Spangenberg (2002) states "there are two antagonistic paradigms: that of the empty world, based upon an economic approach centered on efficiency; and that of the full world, based upon an ecological approach and centered on the intensity of the use of resources". A balance between said paradigms is stated, that of the excessive consumption (environmentally unsustainable) within the sphere of human domination, and within the environmental regulation sphere, the struggle against poverty (socially unsustainable).

Sustainability's final and primordial end consists in finding forms in which human race can live in this planet indefinitely, without compromising its future; given our species' capacity of consciously modify some elements of the interaction with the environment. It is upon these decisions on management and their consequences that the balance nature-society can be founded.

According to Clayton and Radcliffe (1996), "the ample set of environmental, socio-economic and political problems has transcended from a local scale to a global one". This situation leads to conceive new structures, mechanisms of decision making and a new philosophic vision able to understand parts and systems of a world culturally rich and increasingly complex, where "it is necessary the plausible and urgent action of foment-

ing collective action", the link with the ecological systems of the planet, individual identity, respect, social justice and peace (Harrington, 1992).

The transition to a more sustainable way of life needs a significant change in the way the problems are perceived, defined and solved, based on a perspective of open systems, where both problems and solutions will be holistically managed. Hence, the multidisciplinary approach of the complex adaptational systems (CAS) is fundamental, as they are multidimensional, dynamic and evolutive.

Human species' sustainability can only be defined as a final resort in relation to the level of interrelation between the total complex of human and environmental systems directly implicated, so "the study of sustainability requires understanding the systems, particularly human and environmental systems" (Clayton and Radcliffe, 1996).

"Quantifying sustainability from an objective and reductionist approach does not work, as unavoidably an element of circularity appears" (Bell and Morse, 1999). The indicators critically evaluated must include a more holistic, realistic, participative and systemic approach, facing issues such as: measure the immeasurable or bad applications of a good science? Sustainability: a good thing or an empty concept? How can we objectively know when things improve or worsen? "Even if the sustainability indicators (ISs) are a mandate of the Rio Summit (1992), the difficulty is to use relatively simple indicators in something that, as a matter of fact, is very complex" (Bell and Morse, 1999).

Edwards *et al.* (1993) establish that sustainability is an easily measurable phenomenon at community or lot level, however, increasingly difficult at larger scales. For Harrington (1992) sustainability is defined by a set of requirements which must be faced by any lot, despite the great differences in the prevailing situation.

Norgaard (1990) visualizes modernity as a "development's betrayal", whose promises are: control of the nature (science), material abundance (superior technology), effective government (rational social organization), peace and justice (better individual morality) and superior collective culture (for everyone). The author states that "modernity is a philosophical supply for the co-evolutionary process" and its premises are of metaphysical, epistemological and alternative kind. Norgaard expresses that atomism,

mechanicism, objectivism, universalism and monism regulate public opinion, decision making and its implementation; they have been extremely productive for science and institutions, yet they have caused the transformation of the environmental and cultural systems.

The alternative premises include: holism (the parts are united to the whole; the whole is different from the addition of its parts) co-evolution (deterministic, chaotic, discontinuous and co-evolutionary systems), contextualism (contingent phenomena with spatial and temporary variations due to the wide variety of factors), subjectivism (systems linked to activities and present and past human values) and pluralism (complex systems understood by alternative ways of thinking inherently incoherent between each other)

As a consequence of the philosophical stance, this author points out a pragmatic position of modernity that indicates a reality of inequality and bureaucratic inertia, material obsession, descent in the stock of natural resources and environmental degradation, local wars and migration of refugees. This duplicity is exposed in three interrelated ways: material abundance for a few and (current and future) scarcity for the most; a public sector weaker by the day in all of its systems; and global opinion of the modern cultural vacuity, with the reappearance of the cultural ethnical and religious diversity.

Norgaard concludes that "modernity has not been sustainable", as it has caused the suspension of the cultures' co-evolution with their unique environment and adopt the belief in modernity's superiority, validated by the dramatic advances of material welfare. In order to overcome this situation, a complementary response is necessary in the scientific, technological, social, cultural and philosophical aspects in a simultaneous manner, if success is desired. This includes a new social order with neither technocracy nor econocracy; with solid local social organization, decentralization, global responses to global phenomena, ideas' transference, new and correct technologies and organization forms.

Co-evolutive vision considers diverse forms and it is emphasized as the process as an experiment only in the conscious part and in the selection of those things which work properly, and not as a conscious advancement of science and its rational application to the design and implementation of

technologies and social organization.

The later human development will be reached by means of the weakening of the mechanist vision, with no tyranny and destruction of freedom, through a broader philosophical base. Assertion, error, truth and justice will be more difficult to delineate and argument in a more culturally diverse world. Under the approach of systems, the question is, how much can we use our unique human being potential so as to understand our behavior and its consequences in relation to the nature's systemic dynamics? In order to do so, we must be prepared to discard our prejudices and revise each area of human life.

Incorporation of new socio-cultural and economic elements into the ecosystems' analysis: the transition to the ecological value and human welfare

Given sustainability is a concept that requires a holistic vision which involves aspects inherent to the spheres of man interaction (social, economic and political), it is substantial to direct its application to the present and future sustenance of man's environment. In this respect, it will be necessary to lead the effort to improve the quality of life, which is the faithful reflection of the systems' quality and of the defining process of the factors used for evaluating and achieving a territory's sustainability. Hence, the quality of life is the individual happiness and satisfaction with life and environment, including necessities and desires, as well as other tangible and intangible factors that determine welfare.

The importance of the factors varies from individual to individual, its calibration and interpretation represent great difficulty, as it includes from services to recreation and culture. Defining whether a system is in a sustainability state or not is influenced by ethical or value judgments.

"Sustainability must become operational in each specific context, at relevant scales in order to reach it, and appropriate methods should be designed to measure it in the long term" (Masera and López Ridaura, 2000). The central topics are the necessity of a clear definition, attention to Holism and Sustainability, including ecological, social and economic components. The notion of equity includes access to resources, human rights and every activity which contributes to social welfare; the importance of the

scales of time and space lays upon the fact that temporary scale includes both human and ecosystems' scales, and the spatial scale does not only includes the local impacts on people and ecosystems, but those of long distance. The use and development of indicators must be supported upon the measurement of a limited number of variables based on standardized measurements.

Farley and Costanza (2002) define economy as "the localization of scarce resources in the search for alternative ends", and clarify that the first stage in the economic analysis is to determine the desirable ends for society. For them sustainability is "a desirable end with indefinite presence and appearance", which requires resources, necessary market mechanisms and institutions of solid democracy. This is why the ends to be reached must be determined in a democratic manner, and then the necessary resources to achieve it must be determined and finally, decide which the scarcest resources are as well as their localizations.

They suggest that "the vision of the world includes the system of beliefs on the role of us and our experiences in the world" and that it is heavily influenced by the own culture. The vision of the world changes slower than the world and the solutions become part of the problems, the principles of a new vision of the world include we humans are part of the nature, not its owners; nature supports us physically and spiritually, natural resources are scarce, human goals must create life.

This vision of the world contemplates from the complexity approach that results are not always predictable and the irreducible uncertainty dominates the providence of services to support life, from healthy ecosystems. Individualism must be tempered by common interest, individual action must not have any negative impact on the community; society can not be imposed costs for private profit.

With this vision people will pay more attention to other needs and desires such as jubilation, beauty, protection, affection, participation, creativity, freedom, leisure time, identity and understanding. Strong communities favor sustainability more than the limits imposed to excessive consumption.

Clayton and Radcliffe (1996) affirm that "sustainability issue affects all of the spheres of human action and it is founded on principles, theories

and research of technique, economy and politics". In this sense it is fundamentally relevant the multidisciplinary CAS approach. A systematic approach to construct socio-economic systems which fit into and appropriately interact with the planet's ecological systems; it is upon these decisions of handing and their consequences on which this society-nature balance can be based.

From the point of view of the socio-economic sciences there are essential doubts on issues such as the exogenous formation of human preferences; the concept of value; the concept of usefulness and the value of market related to the ecological value of diverse forms of environmental supplies. "The fundamental dilemma is how society can accept external environmental limits and modify its behavior in accordance, or how to assimilate the primacy of values and human welfare" (Farley and Costanza, 2002).

It is required that the implicit value judgments become explicit, so that the current processes become visible. Many of these decisions will be made based on postulations and estimations, as some of their defects will be distant, indirect and diffused. Due to their complexity and sensibility, the applied models are inherently probabilistic and limited.

There can be a number of states which are sustainable at variable degrees, there is a number of ways to reach said states and there will always be more than a possible policy for a transition to a more sustainable way of life; "another key component is to develop a model to transfer information into a form that can be used in the decision-making process" (Clayton and Radcliffe, 1996).

Importance of agro-ecology in the efforts to achieve development, productivity and social usefulness in the long term

Rigby and Cáceres (2001) emphasize that "agriculture implies a holistic vision of the relation between biota, its production and the integral environment". This implies the creation of integrated production systems, human, environmental and economically sustainable.

The challenges agriculture and food production face in the mid and long term seem to be immense; the strategy of agricultural development must be centered on increasing food production and have it available for an increased population, and simultaneously must revert the growing

degradation of resources and the number of people who live in extreme poverty. The strategies for technological development in agriculture need to be directed to the aforementioned topics in such manner that they avoid past frustrations; the most viable and reliable strategy seems to be agro-ecology.

Eco-systemic approaches of the social systems and integral agricultural make agro-ecology unique and controversial, in addition to contribute to our understanding of sciences and development. Agro-ecologists are proposing alternatives to the established conceptions of the relations between society and nature. The philosophical bases of agricultural research and development must start and end with the agriculturists, understanding their perception of the problem and incorporating their evaluation of the solution. Agro-ecology is a discipline in its infancy, which has contributed with more questions than solutions, and which has an ample body of thoughts and influence, and enormous philosophical perspectives (Lampkin, 1998).

Rural poverty frequently leads to desperate strategies to survive, and the attempts to satisfy the urgency of basic needs are a precedent in the short term on the importance of sustainability in the long term. Given the restrictions imposed by their own nature and political environments usually unfavorable, many a poor agriculturists lack access to markets and supplies, as well as credit and appropriate technologies for their environmental conditions or their lot extension conditions. To the extent they struggle to extract from their small lots something to live up, these agriculturists deplete soil.

As a consequence of this, the degradation of every kind of resource (greater deforestation, soil erosion, desertification, flooding and salting, pollution of surface and underground waters, and loss of biodiversity) is on the rise. The continuity of the current rural practices which lead to the degradation of our natural resources will impose serious environmental restrictions to the earth's capacity to feed future generations.

The basic causes for the practices which lead to resources' degradation are the insecurity in property rights, inappropriate systems for the management of resources, deficient institution of critical character, regional and national polices for the short term and a lack of economic mechanisms

which evaluate adequately the natural resources in relation to all of their potentialities, now and in the future (Conway, 1994).

The concept of agricultural performance is an essential determinant of poverty and at the time of the environmental conditions as well as the resources preservation. By agricultural performance it is understood the sector's capacity to contribute to the income and generate employment so as to reach better productivity in agriculture, as well as in other non-agricultural sectors and provide the country's alimentary security (Conway, 1997).

The revaluation of agriculture inside national economies, the reform of international trade, the regional economic integration and urbanization will lead to the relocation of agriculture within national economies and to a restructuration of agricultural production, as a response to a significant increment in the demand of traditional and more diversified products. The abandonment of importing substitution policies after the debt crisis in the early 1980's decade, in favor of the growth model oriented by exportations, has started the process of agriculture relocation inside national economies and created a new demand to intensify agriculture (Lampkin, 1998).

The prevailing strategy of agriculture in the past, known as Green Revolution, was the triumph of technology and a notable economic success which gave as a result a phenomenal increment in food production. As it is pointed out by Conway (1997), "this strategy has been a revolution with serious limitations", its impact in the reduction of poverty has been lower than expected; it has not reduced and in some cases it has encouraged the degradation of natural resources. Its geographic impact has been limited by the regions with favorable environmental, topographic and edaphic conditions.

Conway (1997) proposes to demand a "Double Green Revolution", even more productive than the first one and "greener" in terms of preserving the natural resources and environment. Therefore, future agricultural development must be directed to repeat the success of green revolution at a global scale, in diverse places and be equitable (improving the subsistence means of rural families through incomes related to agriculture and employment-generating activities), sustainable and environmentally

favorable (making the most out of the indigenous, physical, biological and human resources).

Even though Green Revolution took as starting point the challenge of producing new alimentary cultivations of high performance and then looked for determining how the benefits will reach the poor, this new revolution has as a purpose to revert the logical chain, beginning with the socio-economic demands of poor families and then identifying the appropriate research priorities. Its goal is to create alimentary security and sustainable means of subsistence for the poor.

The complex and close interaction between human population and human capital (soil, water, climate, flora and fauna) are fundamental for agriculture. "It is agriculture the sector which reflects more than any other these interactions that include the relations and conflicts between economic growth, poverty and environment (Krishnamurty and Ávila, 1999).

Altieri (2002) defines agro-ecology as the "science of management natural resources for poor farmers in marginal environments". He states that "a fourth part of the world's population remains untouched by modern agricultural technology" and proposes a new management of systems that can be designed and adapted as places specific to the highly variable and diverse agricultural conditions, typical in poor farmers with low economic resources.

Agro-ecology provides the scientific bases to direct production in a bio-diverse agro-ecosystem, able to maintain its own functioning, which implies great institutional and political changes. It is clear that "poor farmers with no resources achieved very little from Green Revolution" (Pearse, 1980), since new technologies were directed to the conditions and environments of agriculturists in developed countries. "the farmers with the least resources frequently had losses and inequalities were frequently stressed" (Shiva, 1991). Not only have poor farmers been excluded from the access to credit, information, technical support and other services, "even in areas where there is access to irrigation and subsidized agrochemicals, inequalities remain" (Lipton and Longhurst, 1989)

"With the aim to guarantee alimentary security in the developing world, the additional production of food must come from systems where the most

of poor people are concentrated" (Conway 1997); "what is opposed to the current polices of World Trade Organization which force poor countries to open their markets and take the overproduction of wealth countries, at prices that discourage local producers" (Mander and Golsmith, 1996).

According to Cambers (1983), "traditional farmers have developed and inherited complex agricultural systems, adapted to local conditions; where the successful agricultural strategies are a tribute to the small agriculturists' creativity". Separately, Gliessman (1998) states "traditional agricultural systems commonly support large plant diversity in the shape of poli-cultivations and agro-forestry". "The strategy to minimize risks planting several plant species and cultivations stabilizes profits in the long run, promotes alimentary diversity and maximizes the recovery, even under lesser technology levels and with limited resources" (Harwood, 1979).

Generally speaking, agricultural labor has high recovery by unit of income. The energetic recovery of the work employed in a typical lot is high enough to secure the current system's continuity. "In these systems there are also favorable return rates between energy inputs and outputs" (Netting, 1993).

It is clear that agricultural modernization has not been helpful to solve the generalized problem of rural poverty nor has it improved the distribution of agricultural land. Small agriculturists, who represent on average 80 percent of the total of agriculturists in Latin America, were left aside from development, as the options offered to modernize agriculture have been inadequate to their needs and possibilities. The projects that boosted agriculture diversification achieved that the use of land was to cultivate exportations, displacing the production of crops for domestic consumption.

The integration of tropical countries into the international market ignores the needs of the local-regional markets and undermines the opportunities to improve the balance of regional trade. A program of alimentary security is needed to establish the bases to reduce massive poverty and create a more equitable and sustainable model of development (Altieri and Nicholls, 2000).

Challenges for agricultural research: toward the study of complex interaction and trans-discipline

The concept of sustainability is useful to understand the concept of agro-ecology for it gathers a set of concerns on agriculture, conceived as a socio-environmental system; these topics' comprehension requires understanding the relation between agriculture and global environment, as rural development depends on the interpretation of bio-physical, technical and socio-economic sub-systems. This broader approach allows understanding the agricultural problem in holistic terms.

The scientific discipline that approach the study of agriculture from an ecological perspective is called "agro-ecology" and it is defined as a theoretical framework whose end is to analyze in a broader manner the agricultural processes; agro-ecological approach considers the agricultural systems as the fundamental units of study. In said systems, mineral cycles, energy transformations and socio-economic relations are researched and analyzed as a whole.

The growing understanding of agro-ecology and ethno-ecology of the traditional farming systems is necessary to continue developing contemporary systems. This can only take place starting from integrative studies that determine the multiple factors that condition the manner in which farmers perceive their environment, thus the way they modify it, to translate then such information into scientific terms.

It is, then, urgent to understand the roots of the causes of poverty and attack such preponderant factors through agricultural research, searching to acquire knowledge on the agro-ecosystems' upon which the poor depend and on how to improve the resilience of the small-holder farming systems. A relevant strategy of Natural Resources Management (NRH) requires the use of general agro-ecological principles and the adaptation of technologies to the local necessities and circumstances. The agro-ecological principles have universal applicability yet "the technological ways by means of which said principles become operational, depend on the prevailing environmental and socio-economic conditions at each place" (Uphoff, 2002).

NRH's strategies for poor agriculturists consider agricultural systems at small scale, diverse and complex with agricultural strategies with traditional

agricultural strategies, which will be environmentally sustainable and base on the use of local resources and native knowledge, if it is really intended to alleviate poverty, secure education and strengthen rural communities by means of the ecological management of their productive resources. With this end "research's priorities must be base on the socio-economic needs and environmental circumstances of the farmers with scarce resources" (Richards, 1985), and it must work from the base of an approach from bottom to top" (Altieri, 1995). All in all, scarce-resource farmers and their complex systems have special challenges of research and demand appropriate technologies (Netting, 1993).

Agro-ecology emphasizes an approach of ecological engineering which consists in assembling the agro-system's components (cultivations, animals, threes and soils). It is sought that temporary and spatial interactions between components become derivate yields of internal sources, nutriments and organic matter recycling, and of trophic relations between plants, insects and pathogenic agents, which stress synergies such as mechanisms of biological control. Hence, agro-ecological research is interested not only in maximizing the production of a particular component, but also the optimization of the whole agro-ecosystem. "This tends to refocus the emphasis on agricultural research beyond disciplinary considerations to complex interpretations between people, cultivations, soil, and animals" (Lampkin, 1998).

In most of the systems with multiple cultivations developed by small land holders, productivity in terms of harvestable products by unit of area "is greater than in single cultivation with the same management level" (Francis, 1986), and "represent an important resource for modern workers who try to create a novel agro-ecosystem, well adapted to the local agro-ecological and socio-economic circumstances" (Dewalt, 1994).

"The techniques tend to be intensive in knowledge, rather than intensive in supplies" (Reintjes *et al*., 1986), however, clearly not all of them are affective and applicable, so modifications and adaptations are necessary.

By means of the maintenance of a lot's mosaic under cultivation and some unused, farmers have grasped the essence of the natural processes of soil recovery, typical in any ecologic succession. Additionally, some sys-

tems tend to decrease the stress of drought, because of the protective layers left by certain cultivations, since they help water to remain in the soil's profile.

Thus far research has been comfortably oriented toward the goal of increasing livestock and particular alimentary cultivations' performance, generally without the adequate understanding of the needs and options of the poor, or the ecological context of the systems they are directed to. A new strategy of Integrated Management of Natural Resources (IMNR) must generate a new approach that considers the interactive effects of the ecological and socio-economic systems at eco-regional level, under two main definitions: responsible management with broad foundation on the base of biological resources, of land, water, and forest; and management of biogeochemical processes (Mander and Goldsmith, 1996).

Agro-biodiversity and agro-ecology: surpassing the mechanicism

"Agro-biodiversity is still treated as a black box in agricultural research" (Swift and Anderson, 1993); it is important to look for elements for production, with agro-ecosystems' management forms sensible to the maintenance and increment of bio-diversity (associated cultivations, rotating cultivations and agro-forestry). The soils with high content of organic matter and high biological activity generally have good fertility, as well as nutritional complexes and beneficial organism which prevent infections; thus, the importance of the application of organic manures; separately, "the agricultural practices that cause nutritional imbalance can decrease plague resistance" (Slansky and Rodríguez, 1987; Magdoff and Van Es, 2000).

Agro-ecosystems, then, can be manipulated in order to improve production and produce more sustainability with less negative environmental and social impacts, such as biodiversity diminution, loss of soil fertility and water pollution, with the consequential damages to the agro-ecosystem and rural producers' health; and less external supplies which represent increments in the production costs affecting farming economy.

The ecological concepts are used to favor the natural processes and the biological interactions that optimize synergies; in such manner that the diversified fields are able to backup their very edaphic fertility, the protec-

tion of cultivations and their productivity. By means of the assembly of cultivations, animals, threes, soils and other factors in diversified spatial-temporary schemas, several processes are optimized; said processes are crucial in determining agricultural systems' sustainability (Vandermeer *et al.*, 1998).

"Agro-ecology has great advantages, as for natural processes and beneficial interactions inside the place, so as to reduce the use of supplies alien to the place and optimize the efficiency of the cultivation systems" (Reintjes *et al.*, 1992); this necessarily is reflected on the producers' economic and social welfare.

It is necessary that agronomists understand the socio-cultural and economic elements of the agro-ecosystems, and at the time, the social scientists appreciate the technical and ecological elements in them. "Agro-ecology provides ecological bases for biodiversity's preservation in agriculture" (Altieri, 1995). Besides, it has a role in the reestablishing of the agro-ecosystems' ecological balance, in order to reach sustainable production.

Temporary and spatial interactions in agro-ecology: beyond reductionism

The rotation of cultivations establishes temporary sequences wherefrom large nutritional contributions are obtained when cereals are rotated with leguminosae, and insects, weeds and infections are regulated, when breaking the cultivations in sequence and their lifecycles. By means of well-designed rotations, yields can be improved and reduce other energy requirements, as the need for fertilizers is reduced, with notorious benefits for the agriculturists. For instance, the incorporation of alfalfa in a rotation with maize can reduce the energy inputs in 39 percent. Many rotations do not require major modifications to the existing production patterns" (Altieri, 1995). Conversely, rotations of high cost of supplies and labor can be designed.

The yields' increments are derived from certain changes in the designs and spatial and temporary arrays, such as the case of the poli-cultivations universally used by farmers. When cultivating several species simultaneously, multiple management objectives are achieved, with no further subsidy or

complementation. Intercalated cultivations reduce the incidence of weed, plagues and infections, improve soils' quality and make the use of water and nutrients more efficient, increase land's productivity and reduce yield's variability (Francis, 1986). This, undoubtedly, has implications in farming economy and offers opportunities to improve the producers' quality of life.

The behavior of a plot is determined by the level of interactions between their diverse biotic and abiotic components. The interactions that move the system are those where certain products or results from a component are used for the production of others (for instance weeds used as livestock forage, excrements as manure in cultivations, stubble of cultivations used as shelter and mixtures of manure and straw for compost). The intensity of the benefits derived from these interactions depend on how well organized the diverse components are, and on an adequate management that allows the recirculation of resources at the plot's level.

The challenge is to preserve enough flexibility to permit the adaptation to environmental and socio-economic changes from the outside. To the extent the thresholds of social and ecological "impoverishment" of a system are defined, a model of development that minimizes the degradation of the ecological base which supports the quality of human life and the function of the ecosystems as services and food's suppliers can be determined; in order to achieve this, the processes of biological transformation must be directed to a sustainable development which does not impoverish a group while makes wealth another, and do not destroy the ecological base that supports productivity and biodiversity, as the current tendency in Mexico seems to be.

The approach of analogy with natural ecosystems, multi-specificity and facilitation: toward an eco-systemic vision

"In the core of the agro-ecological strategy lays the idea that an agro-ecosystem must imitate the functioning of local ecosystems", exhibiting nutrients' recycling, complex structure and growing biodiversity (Ewel, 1999); the method of analogical succession requires a detailed description and the botanical characterization of all the potential component cultivations. It is here where ethno-biology and its main branches appear: ethno-botany and ethno-zoology.

For temperate climates, Soule and Piper (1992) propose the use of vast prairies of North America as an appropriate model to develop ecosystems dominated by mixtures of perennial grasses, leguminosae and compounded, plants that differ in the seasonal use of nutrients and therefore, must have complementary and facilitating roles in the countryside.

The use of perennial species must imitate the original aspects of retention and construction of soils of a prairie. The leguminosae component must help preserve an internal contribution of soil fertility and the diversity of cultivated species, including some native species. "It must lead to the development of natural controls and balance of herbivores, infections and weeds" (Jackson, 2002); being soil the base of richness and fertility of the agro-ecosystem. These principles provide economic benefits to the producers and strengthen their social base.

The approach of the analogical ecosystem is the base for the promotion of agro-forestal systems, specially the construction of agro-ecosystems with forest, which imitate the vegetal succession and exhibit low fertilization requirements, high use of available nutrients and high protection against pests (Sánchez, 1995). The economic and social benefits of agro-forestry have been widely discussed by Krishnamurty and Ávila (1999), and include a broad diversity of products (wood, foliage, fruit, resins, fuel and forages) and uncountable environmental services (climatic, hydrologic, edaphic, ecologic) and human (ethic, and aesthetic).

Diverse agricultural studies have shown the complexity of multi-specific agricultural systems, as "they are more reliable in their production and more sustainable in terms of resources preservation than simplified agro-ecosystems" (Vandermeer *et al*., 1998), with natural resources as base for agricultural production. These advantages undeniably become economic benefits for the producers; the mechanisms that result in greater productivity in diverse agro-ecosystems are to be found in the processes of facilitation: this occurs when a plantation modifies the environment so that it benefits other cultivation.

An aspect of great interest is that the current over-yield rate increases with water stress, in such manner that the relative differences in productivity between mono-cultivations and poli-cultivations becomes more marked, in accordance with the stress increment. Research, carried out in hilly zones

after Central America experienced Mitch hurricane, showed that farmers who used sustainable practices, such as coverage cultivations, intercalated cultivations, and agro-forestry, suffered fewer damages than their conventional neighbors. "Sustainable practices had from 20 to 40 percent more superficial soil, greater edaphic humidity and experienced lesser economic losses" (Holt-Gimenez, 2001). With this the NRH's strategies which privilege temporary and spatial diversification of cultivation systems are founded so that they lead to a better productivity and, likewise, better ecologic stability and resilience, which is translated into welfare and social stability.

Spatial and temporary diversification: integrating effects

"The benefits of multi-specific rotations, coverage cultivations, agro-forestry, and intercalated cultivations have been already identified" (Francis, 1986). The beneficial effects of acid soil substances on the growth of plants are mediated by series of a series of mechanisms, many of them similar to those resulting from the direct application of synthetic regulators of the vegetal growth, which notably increment the costs of production.

"Soils rich in organic matter generally exhibit good edaphic fertility, as well as complex trophic networks and beneficial organisms" (Hendrix *et al.*, 1990), which prevent infection caused by pathogenic organisms; "compost can positively affect plant resistance to infections" (Trankner, 1992). As a matter of fact, there is evidence that "cultivations that grow in soils rich in organic material and biologically active are less susceptible to the attack of pests" (Luna 1988), whose control constitutes in many cases a relevant additional cost.

The literature is abundant on the benefits of the additions of organic amends, which stimulate the antagonist residents as they promote the biological control of vegetal diseases. Campbell (1989) and Liebman and Gallandt (1997) have suggested delayed patterns of nitrogen availability in systems with low external supplies can favor large-seed cultivations crops upon small-seed weed. They have also found that the addition of organic materials can change incidence and severity of diseases with edaphic origin, which affect weed but not to cultivations. Such results suggests these ubiquitous mechanisms for soils organically handled can decrease weed's den-

sity and growth, preserving cultivation acceptable yields, at very low costs.

Altieri and Letourneau (1982) and Andow (1991) have carried out experiments that prove the theory of reduced vegetal diversity in agro-ecosystems leads to growing abundance of pathogenic insects, which usually exhibit greater abundance in mono-cultivations than in diversified cultivations systems (Altieri, 1994) and represent large economic losses for producers and damages to the ecosystem's health.

Two main ecologic hypotheses (that of the natural enemies and that of the concentration of resources) have offered explanations on the reason why the communities of insects in agro-ecosystems can be stabilized constructing vegetal architectures, which foment natural enemies and directly inhibit the attack of pests (Smith and McSorely, 2000), preventing the producer from derivative costs from the control practices and the subsequent environmental impacts. It is clear that empirical data and theoretical argumentations suggest that the differences in the abundance of pests between diverse and simple systems of yearly cultivations can be explained by both the differences in the herbivores' mobility, colonization and reproduction behaviors, and the activities of the natural enemies. The studies suggest that the more diverse the agro-ecosystems and longer the time this diversity remains unperturbed, the most internal links are developed, the greater stability before insects, preventing them from becoming a plague, with subsequent economic costs (Altieri and Nicholls, 1999).

More studies are necessary to determine the subjacent elements in the vegetal mixtures, which interrupt the invasion of pests and favor natural enemies. Research must also be expanded in order to evaluate the effects of genetic diversity, reached by means of a variety of mixtures, the suppression of vegetal pathogens, whose control does not only increase production costs, but also has generated high pollution levels in water and food, with noxious effects on human health.

Redesign of systems: a challenge for Mexico

The conversion to a system with low external supplies is a transition process with three marked stages: a) growing efficiency in the use of supplies, through the integrated management of plagues and the integral management of soil fertility; b) supply substitution by environmentally benign supplies; c)

redesign of the system and diversification with an optimal cultivation / animal assembly, which promotes synergism (McRae *et al.*, 1990). The objective is that the agro-ecosystem can improve its own edaphic fertility, the natural regulation of plagues and cultivations' productivity, decisive factors for the benefit obtained by producers. Many of the practices which are frequently promoted as components of sustainable fall into the two fist categories. Both stages offer clear benefits in terms of lesser environmental impacts, as they cause the diminution of agrochemical supplies' usage and often provide economic advantages compared to the conventional systems.

Gradual changes seem to be more acceptable for farmers, given that drastic modifications can be seen as highly risky. The question is whether the adoption of practices increase the efficiency of supplies' use, of that they substitute biological supplies with agrochemicals, however, they leave the mono-cultivation structure intact; really have the potential to lead to the redesign of agricultural systems. Thus far the substitution of supplies has lost its potential in favor of the poor. According to Altieri (2002), "a notorious exception are the advancements in Cuba", where artisan production at small scale of bio-pesticides and bio-fertilizers is performed in cooperatives, using local materials and is available for farmers at low cost.

The redesign of systems, on its own, must secure the following processes: increment of biodiversity upon and under the ground, increment in biomass production and content of organic matter in the soil, optimal planning of the sequence and plant / animal combination, efficient use of locally available resources and the optimization of the complementary functionalities between several agricultural components. The design lineaments can be later developed and used to optimize the sustainability of agro-ecosystems and resource preservation.

Despite the success of many of the systems of organic production and low supplies in the practice, one of the causes of the failure of research on sustainable agriculture has been the incapacity to experimentally compare, "side to side", conventional practices with low-supply practices (Vandemeer, 1997).

The diversity of technologies of cultivation and plague management practices results into functional differences, which cannot be quantified by

any isolated practice. A "syndrome of production" is a set of management practices that are mutually adaptable and lead to high efficiency. The subsets of practices can be less adaptable, as the interaction between practices leads to the optimization of improved systems.

Each production system represents a different group of management techniques and the implied ecologic relations. This emphasizes the fact that agro-ecological design is specific for each place, and what can be applicable into other places are not the techniques, but the ecologic principles which lay in sustainability. Technology transfer from a place to another is not useful if the set of associated ecologic relations with said techniques can not be reapplied.

The institutions and their importance in the research and promotion of agro-ecologic practice

Plenty of institutions have forged a niche adopting the motto "produce preserving and preserve producing". What is important is to clarify that it is not another attempt to fit the environmental issue into the agricultural regimes already established, but to aim for a real synergy between ecology, economy, and forest-agricultural science. Concreting this vision will mean to reorient agricultural research and teaching in order to face the challenges of the large number of poor farmers and their fragile ecosystems, also securing the sustainability of the areas of intensive production.

In order to do so, it will be necessary to introduce ecological rationality to agriculture oriented to minimize the use of agrochemical supplies, complement the programs of water, soils and biodiversity preservation, plan the productive landscape in function of soils' potentialities in each region and promote sustainable management of forests and other renewable and non-renewable resources.

The crucial mission of public institutions, in direct relation to the agricultural producers, must be centered on securing that the poor will not be excluded from the benefits of development. This will mean that equity must reach rural communities through real opportunities, so that they can be the protagonists of the countryside problems' solution. Offering opportunities means revaluing traditional inventiveness and local organization-participation, and make available for farmers of all strata tech-

nological alternatives (many of them originated by the very farmers), "which are compatible with the resources they have at hand and training so that they know how to apply and diffuse them, in order to gradually introduce sustainable agriculture" (Pretty, 1995).

One of the features that has characterized agro-ecology in its search for new practices of agricultural development and strategies of resources management is the knowledge local agriculturists have on their environment, plants, soils and ecological processes, which acquires an unseen importance within this new paradigm. Different groups are convinced that understanding the cultural and ecological features characteristic of traditional agriculture, such as the capacity to avoid risks, popular biological taxonomies, the production efficiency of symbiotic cultivations and the use of local plants to control plagues, is of the utmost importance to obtain useful and pertinent information which leads the development of appropriate agricultural strategies, more sensible to the complexities of farming agriculture as well as being custom-made for specific farming groups and regional agro-ecosystems.

Agricultural research and development must operate upon the base of a "from-the-bottom" approach, starting with that which is already there: the people from the place, their needs and aspirations, their agricultural knowledge and autochthonous natural resources. It is evident that improving the access of farmers to land, water and other natural resources, as well as equitable credit, fair markets and appropriate technologies are crucial to guarantee a sustainable development.

How to develop and promote new technologies adapted to farming agriculture is the unavoidable challenge for agro-ecology. This challenge can only be faced adopting an agro-ecologic strategy in rural development that systematically emphasizes the relations between environmental, technical, socio-economical and cultural variables, which affect the use and production of local resources. "When new agro-systems are designed, the interactions between the individuals and their local environment, the spatial and temporary patterns of the productive activities, social relations of production and the interaction between communities and the outside world must be considered" (Krishnamurty and Ávila, 1999).

It is evident that the poorer the agriculturist, the greater the importance of the use of low-supply technology, as they have no other option but to draw to the efficient use of their local resources. Under conditions of economic subsidy, credit or if they have plain soils and access to irrigation, green revolution becomes more attractive for agriculturists, as in the short term it seems to offer more spectacular yields. The question is what is the social and environmental cost? And, how long must the system be subsidized? This discrepancy would be nonexistent is there were research and extension centers at national level that promoted agro-ecology with as much energy as currently the governmental institutions foster chemical and mechanized agriculture.

The immediate problem in many areas of rural poverty lays on the survival of the farmers, so preserving subsistence farming is absolutely essential for the rural population's welfare. A farming population with alimentary security, social organization, a preserved base of natural resources and cultural identity is in a better position to negotiate with the local or national power.

The increment of participation of farmers in local markets will only be achieved once their basic survival needs are secured. What is basically sought is to promote the alimentary self-sufficiency of the farming population, leaving the specialized agriculture, oriented to exportation, aside and replacing it with a model that recognizes in ecological and cultural diversity of each place the key elements for the appropriation and transformation of nature.

To the extent that these programs are evaluated, it is proved that farmers who adopt the proposed designs enjoy greater alimentary self-sufficiency and consolidate at communal level, when reciprocally collaborate in labor and other activities. What is more, it is obvious that model systems are not taken by the farmers as rigid technical recipes. These recipes fulfill a rather pedagogical function providing the farmers with ideas and criteria they will apply in their lands in the way they consider the most appropriate.

Spangenberg *et al.* (2002) clarify that governmental organization generally are explicitly referred as institutions, which in the course of making decisions must consider aspects of sustainable development. The use of terms related

to institutional contexts in Agenda 21, implies that the institutions' subjacent comprehension is broad, as it does not only refer to organizations but also to institutional mechanisms, such as procedures and legal regulations (systems of formal or informal rules, explicit or implicit). This analysis leaves several important institutional aspects of sustainable development uncovered, which are not reflected on the set of institutional indicators.

Applications, limitations, potentialities and perspectives of agro-ecology

The application of agro-ecology to the improvement of the productivity of systems of small agriculturists has been very diverse; the alternative approaches stated can be described as low-supply technologies, referred this designation to the external supplies required. The amount of labor, abilities and management needed as supplies to make land more productive and other factors of production are substantial. So, instead of focusing on that which is not being used, it is better to focus on what is important to increase food production, labor, knowledge and management (Uphoff and Altieri, 1999).

Alternative agro-ecologic approaches are based, as much as possible, on the use of locally available products, even if it does not completely rejects the use of external supplies. Farmers cannot be benefitted from technologies out of their reach and which are not appropriate for their conditions.

Besides increasing diversity and alimentary security, the use of practices of sustainable agriculture reports increments from 50 to 100 percent in food production per hectare. Agro-ecologic approaches increase production stability, as "it has been observed in lesser variance coefficients in the performance of cultivations with better soil and water management" (Francis, 1986). It is difficult in any case, to quantify all the potential in said diversified and intensified systems, since there is very little research and experience to establish limits.

A basic obstacle for the use of agro-ecology is the demand for specificity in its application. Agro-ecologic systems require their principles to be creatively applied inside each agro-ecosystem in particular. "The people

who practice it in the land must have more diversified information on ecology and agricultural and social sciences in general" (Pearse, 1980).

The high variability of the ecological processes and their interactions with heterogeneous social, cultural, political and economic factors generates exceptional local systems. Then, "the only way in which the specificity of the local systems can be taken into account is by means of natural resources management (NRM) for specific places" (Edwards *et al*., 1993).

It is necessary to understand the principles that explain why such schemas work at local level, and then apply said principles at larger scales. NRM's specificity at the level place requires a body of knowledge exceptionally ample, which a research institution cannot generate and manage on its own. This is a reason why the inclusion of local communities, in all of the stages of the project (design, experimentation, technological development, evaluation and diffusion), is a key element for a successful rural development. "Inventive self-validation of rural populations is a resource which must be urgently and effectively fomented" (Richards, 1985). There are many other factors that limit the implementation of initiatives on sustainable agriculture, one of them is that research and development for agro-ecology and sustainable approaches have been ignored for long or even immobilized (Pretty, 1995). Evidence shows that "sustainable agricultural systems can be economically, environmentally and socially viable, as well as positively contribute to local support" (Uphoff and Altieri, 1999).

According to Pretty and Hine (2001), the factors for the success of agro-ecological innovations are: appropriate techniques adapted to farming experimentation, participant approaches and social learning, adequate links between farmers and external agents and presence of social capital at local level. A factor that limits the diffusion of agro-ecologic innovations is the lack of analysis and systematization of the principles that determine the success level of local initiatives, so there is not capacity to validate specific strategies for the publication of said initiatives. A starting point must be the understanding of the agro-ecologic and socio-economic conditions under which the alternatives were adopted and implemented at local level, including the systematization and application of successful approaches at local level and the removal of limiting factors.

In order for sustainable agriculture to be diffused to a larger number of farmers and communities in the future, attention must be paid to make it sure that environmental policies will be permissive, rather than restrictive; broaden investment on infrastructure for markets, transport and communication; secure support from governmental agencies, in particular for the local initiatives of sustainable agriculture; and develop social capital both inside rural communities and people from external agencies.

Undoubtedly, "small agriculturists in marginal environments in the developing world can produce a large part of the food they need" (Uphoff and Altieri, 1999; Pretty and Hine, 2001), thus increasing stability in production through diversification, in improving diet and income. This will contribute to alimentary security and exportations, at the time to the preservation of natural resources and agro-biodiversity.

"The new strategies must be focused on facilitating the learning of the farmers", so as they become experts in NRM and in the seizing of opportunities in their diverse environments (Uphoff, 2002). This implies a clear comprehension of both the relation between biodiversity and the functioning of the agro-ecosystem and the identification of management and design practices that optimize the correct sort of biodiversity, which in time will contribute to the maintenance and productivity of the agro-ecosystem (Toledo, 2000).

Special emphasis must be made on the farmers' direct involvement into the formulation of the research agenda and on their direct active participation in the process of technologic innovation and diffusion. The adequate direction, local research and capacities must be used in order to solve problems; in addition the control on the alimentary system must be optimized.

Governments and international public organizations must promote and support the effective cooperation between NGO's, local universities and farming organizations, so as to help strengthen poor farmers so that they reach alimentary security, income generation and preserve their natural resources. According to Altieri (2002), "the ultimate challenge is to increase investment and research on agro-ecology and develop new projects which thus far have proved to be successful for thousands of other farmers.

Current state of the debate on sustainability

"World's over-economization has provoked the homogenization of production and consumption patterns, against planetary sustainability based on ecologic and cultural diversity" (Morales, 2004). Nature is made a thing, "denaturalized" from its complexity and transformed in raw material (natural capital). We have even reached conservationist exploitation of nature, which separates biodiversity in its function of ecologic balance and its role as germo-plasma banc.

Economic globalization is s superior state of the process of the capital's accumulation and internationalization, which discharges in nature the rejects of the "destructive creation" of capital (Leff, 2003).

Trans-economy is an inertia that has overflowed its limits. Economic rationality lacks flexibility to adjust ecological sustainability; the most important reasons are those of the market. The limit law of economic growth is disavowed and the debate has been displaced to political ecology and not to ecological economy.

Nature's political and cultural re-signification is sought to survive, as new forms of intervention in the natural world and new manifestations of impacts and risks have appeared. Concepts reserved for scientists are used in the official rhetoric; not only are capital, labor and technologies mentioned, now also territory, autonomy and culture enter the rhetoric debate. "Nature is thrown into the sphere of simulation of the economy trans-substantiated in capital" (Ezcurra, 2003).

Anthropogenic alterations are qualified as natural disasters. Uncertainty in economic and environmental processes grows, as well as the inefficacy of public policies and opposed interests. "Technologic dependence is intensified and sustainable development is a myth" (Guzmán, 2004).

"Sustainability has become a process of social struggles and environmental conflicts for the appropriation and productive management of biodiversity" (Leff, 2003). The capure of carbon dioxide, petroleum, aesthetic resources and genetic richness are inexpensively sold, which deepens the differences between wealthy ad poor countries under sustainable development.

A possible solution is the deconstruction of the economic rationality and the construction of an eco-technologic rationality supported by the productive potential of the ecosystems. Based on the ethic of sustainability, where value and territory are perceived as the policy of the place and the difference; where identity, autonomy and territory are based on the survival of the cultural diversity and quality of life; where the policy of being, of the becoming and of the transformation are founded upon cultural territories with reconstruction of identies. The struggle for biodiversity is a right to be different, provides singularity and autonomy in the search for the equity and justice, which propitiate the valuing of environment and nature's re-appropriation (Morales, 2003).

The current state in the debate on sustainability is that of the desired and unachieved; the planned and unreached in the social, environmental, cultural, technologic, economic. It is a multi-causal phenomenon characterized by its multi-dimensionality and multi-factorability in the search for intergenerational equity, and whose challenges are to procure and sustain welfare for everyone (Coke, 1996).

Nowadays, inequality, injustice and environmental deterioration found the critical environmental discourse of growth, against economic rationality and the search for ecologic sustainability. This is the condition of ethnic and cultural diversity against economic and biotechnological sustainability.

The concept is diluted, recodes men and their culture and nature, as forms of the same essence, the capital, based on a production guided by the logic of market, whose characteristics are delirium and inertia of growth and the rhetoric of sustainability.

If the preferences of future generations are not updated, the sustainability of capitalism is impossible. "Nowadays the strategies of seduction and simulation replace direct violence with psychological violence; economic domination is achieved by means of consumption and preferences" (Leff, 2003).

The opposed to the dialectic of development are the environment and economic growth; the transition from the anti-ecological economic order toward a new social order requires ecological sustainability, participative democracy and environmental rationality. This will allow the change from the legitimization of capitalization to the valuing of social costs (Leff, 2003).

Thus far the deterioration has been documented and there has been little action. It is known that there is a power growingly concentrated, ubiquitous and technologized. We have lost the notion of equilibrium; the market has fomented poverty with dignity, as the free market is socially insensitive. "Sharing wealth and consolidate citizen-becoming are requirements of development, as well as the management of the spheres of community" (Morales, 2003).

Science has resolved the immediate putting in risk the long term. University generates knowledge and professionals which make decisions disregarding the emergent realities product of confluence and articulation. The subordination of the university labor to the political logic, subjected to market's tyranny, has been fomented. Science has been segregated and atomized, subjected to utilitarianism and destined to neuter intellectual power. The dialogue between the fields of knowledge has been blocked and complicated by a fragmented and sectioned thought (Guzmán, 2004).

Conclusions

Balance between natural and social systems is the fundamental requirement to achieve sustainability, as excessive consumption affects environmental sustainability and poverty does it to social sustainability. Co-evolutive vision of both systems allows understanding the interactions and influences that can favor this balance, for they explain how environment and society affect one another, both in the sense of development and degradation.

In recent studies it has been established that the incorporation of socio-cultural and economic elements into the analysis of the ecosystems is indispensable, if an integral and more complete understanding of them is desired. It is clear now that the style of development and preferences of consumption exercise different sorts of pressure on natural resources and the environment. The transition from the market value to the ecologic one and to human welfare requires a new vision of the world, which alternative premises such as holism, co-evolution, contextualism, subjectivism and pluralism in relation to the environment, society and their relations is based on high values of equity and liberty.

The comprehension of the ecosystems and in particular of the agro-

ecosystems, focused on achieving sustainability, cannot be approached in a partial and disciplinary manner, multi- and inter-discipline are needed in order to achieve it; this implies the inclusion of the agriculturist in the perception of problems and the evaluation of solutions, with a serious participative approach, from "bottom to top".

Agro-ecology has been considered as an important alternative to achieve development, productivity and social usefulness in the long term. However, the advancement of this science means humongous challenges for agricultural research, which must deepen into the study of complex interactions, going beyond any mechanismic and reductionist approach, in the search for an eco-systemic vision able to identify and propitiate integrating effects for the redesign of systems.

In this challenge, the institutions devoted to agricultural research and promotion have a significant role, if the development of the agricultural science is desired, which in spite of enormous applications and potentialities still has limited perspectives due to the large conceptual and methodological obstacles the conventional approaches offer. Among these limits one finds the lack of specificity for local systems, the amplitude of the knowledge body and the little relevance given to the rural population's self-validation of the participant approaches and social learning. The analysis and systematization of principles that determine the success of local initiatives, are required, as well as the agro-ecological and socio-cultural conditions where they develop; farmers' active participation must be included in the formulation of research agendas and in the process of technological innovation and diffusion.

Finally, sustainable development and particularly agriculture sustainability imply substantial changes in all the related sciences' paradigms, nevertheless, also in the ethical stance of the actors involved into its realization.

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Sent to dictum: February 9th, 2007
Re-sent: June 15th, 2007
Re-sent: August 7th, 2007
Approval: August 23rd, 2007