

**Appendix 1.** Some theoretical currents and concepts for analyzing the society-nature relationship.

### *Human Ecology perspective*

Human ecology can encompass such diversity of theoretical and methodological foci, that some researchers approach it from a particular discipline while others treat it as a convergence of disciplines; it has also been considered a research tool, a theoretical-methodological problem and/or a goal to be achieved (Cervera 1996). This author observes that in the state of Yucatan, Mexico, the human ecology paradigm has been applied to research about social uses of ecosystems and the biological condition of human populations in response to the availability of natural resources. We conceive human ecology perspective as an interdisciplinary approach for researching the relationship between humans and nature, and the reciprocal effects this involves. This approach let us understand the effects of the biological and sociocultural heritage that had influence in the corporal composition of human beings and the developed of cultural elements, both facts, allowed the development of communication and collective organization to appropriate nature.

Under the above perspective, we review some of the theories and concepts relevant to the natural and psycho-sociocultural environments in which individuals use and develop their natural knowledge of resources under the influence of family and community. First, we focus on biodiversity and complexity in socio-ecological systems, including the bio-cultural memory of populations and how erode or conserved nature.

### **Complexity in socio-ecological systems**

To encourage a sense of duty towards and responsibility for the conservation and protection of a dynamic-chaotic nature requires clarification of the ideologies and goals behind individuals' and society's perceptions, thoughts and actions.

Humans' interaction with nature is diverse and largely conditioned by the species' drive to satisfy their needs. However, humans also interact with nature through their appreciation of it, which depends on aspects like perceptions, emotions, knowledge, beliefs, values, culture, economy, politics, ethics, aesthetics and spirituality. Considering humans' almost complete occupation of the planet, and their interactions with it, an ecosystem unaffected by humans may not exist. In time and space, appreciation of nature can also contribute to biodiversity erosion or conservation; through irresponsible resources use in the first case or conscientious restoration activities in the second. For instance, the Tharaka farmers of Mount Kenya have a positive influence on crop diversity by conserving their crops in situ, efficiently managing transmission practices and seed exchange selection, and thus ensuring their food security (Labeyrie et al 2014).

The study of interaction process between society and nature beside complex; has a strong and historical background and shows how the environment and nature biodiversity have

affected weather, temperature, altitude, ultraviolet radiation, flora, fauna and, human bodies (Beall and Steegmann 2000) the last one also manifested this relation in diet, physical activity, body size and reproduction (Volland 1993).

### **Culture-identity, ecological traditional knowledge and sustainable management of natural resources**

Culture is a “knowledge system which, as a model of the reality, provides order, coherence, interaction and direction to social action of members of a society” (Aguirre, 1982: 149). Knowledge systems are complex, and allow to identify information, know, practice, value, teach reality and generate identities, according to cultural elements of specific groups; are historical and in constant movement and evolution (Castillo et al 1997). In this article, we refer to knowledge and use of biological and cultural diversity, indicated by Terán (2010), when analyzing the agricultural and productive strategy in the milpa of the Mayas from Yucatán, which gives them identity and is expressed in three levels: technical, productive and sociocultural.

The contributions of Toledo (1992), Berkes, Colding and Folke (2010), and Terán (2010) allow us to identify groups of traditional ecological knowledge, the practices that are performed and the underlying knowledge of agricultural and ecological principles: (1) diversity, (2) self-sufficiency (3) integration (4) fairness (5) economic justice, (6) special equilibrium, (7) productive equilibrium, (8) community equilibrium, (9) family equilibrium, and we add (10) individual equilibrium.

Studies of the nature appropriation by Yucatecan Maya population; shows mutual influences between societies, environment and nature. An info-graphic synthesis explain the detailed process of their agro-ecological practices: there is a close relationship between knowledge (*corpus*), productive practices (*praxis*) and Maya Cosmo-vision (*kosmos*), oriented and organized in a sacred geography of the universe, in three worlds: *supra*, *infra* and *real*, represented by four “cosmic” trees, each one for a cardinal point and one more for central cycles dinamized for night and day and, years’ stations (Alarcón-Cháires and Toledo, 2013: 17).

Alarcón-Cháires and Toledo’s research (2013) showed a vision associated to ideas of equilibrium, that we referred as harmony and health, expressed in celebration at multi-scale world view of religious rites: nature, human body, altar, home, backyards or solar, “*milpa*”, and the whole world. This Yucatecan Maya cosmovision is in their knowledge about vegetation units and relationships with their soil, it is fundamental to the knowledge of the landscapes, strategies selection and decision making of the farmer. In the knowledge about the appropriation of nature, the dynamics of ecological succession and reclamation of jungles underlie, fundamental for handling local natural resources.

*Culture and Maya identity*

Another contribution to this framework comes from the theories and concepts of the social construction of reality and gender, which are useful in clarifying differences between the primary and secondary socialization of men and women. Constructivism and social learning theory contribute to understanding sociocultural learning and behavioral modeling. The capability approach is useful for identifying in the study participant's transformation of knowledge and skills on natural resources use and management. The cultural capital theory clarifies the internalization and externalization processes of different forms of knowledge in individuals and community member understanding of natural resources use and management is enriched.

#### *Role of the family in the transmission of social knowledge*

Individuals engage in informal education on a daily basis, by incorporating knowledge in two main categories: (1) social thought about one's self and others, beliefs, opinions and attitudes; and (2) biological and cultural influences that shape the behavior, persuasive pressures, social behavior, group guidelines, and social relationships underlying the construction of social reality (Faure et al. 1972; Myers 2008).

As a social space, the family responds to external demands and fulfills a double function (Martín 2000): (1) it helps to explore and integrate the biological processes that accompany physical, motor, sensory, perceptual, cognitive and verbal development in the individual (Santrock 2007); and (2) it is the mediating ambit between individuals and global society (Martín 2000). From the human ecology perspective, the family is understood as a fundamental ecological unit which functions as a "buffer or mediator between the individual and large groups, it is a humans' source of identity and support" (Young 1991:21). It experiences internal and external influences that are decisive in individual growth and development; for example, the family environment, living conditions, income, parents' ages, and emotional and cultural background (Wolanski 1995). As the first and primary educational institution (Gómez 1997), the family sets the context for human development, since it is here where children acquire most of the stimuli and learning vital to their existence (Bonfenbrenner 1986, Kaminsky 2001). One of its most important functions is primary socialization.

#### *Socialization and construction of the psycho-sociocultural reality*

During socialization, individuals internalize the world in which they live, learning the guidelines, values and feelings needed to identify with others and function in society. This process tends to occur in two stages: primary socialization during childhood; and secondary socialization or re-socialization during adulthood (Berger and Luckmann 1967, Frederick 1992).

Reality has been defined as "a quality appertaining to phenomena that we recognize as having an independent being of our own volition (we cannot 'wish them away'), and to define 'knowledge' as the certainty that phenomena are real and that they possess specific

characteristics” (Berger and Luckmann 1967:13). Children build their reality via interactions, in a world of objectifications provided by language, and form an identity based on inter-subjectivities (Berger and Luckmann 1967). To understand that society moves through inter-subjectivities, children internalize their first world, the only one that exists during primary socialization, thus creating in their consciousness “...a progressive abstraction from the roles and attitudes of specific others to roles and attitudes *in general*” (Berger and Luckmann 1967:152). Children learn group guidelines through other individuals, although the mother and other family members are especially important for development (Bandura 1969, Frederick 1992).

These figures serve as models (Bandura 1969) and maintain emotional links, becoming “significant others” (Frederick 1992). In social learning theory, the model displays a behavioral, attitudinal or emotional reaction which is reinforced (Bandura 1969). The observer learns different kinds of behavior, matching them to those of the model.

Learning mechanisms require proximity to verbal, symbolic stimuli and/or observed codes of stimulus. Behavior is controlled using reinforcing, self-administered or vicariously experienced external events. When the process is complete, the model needs to be reinforced for the apprentice to display the imitated behavior.

#### *Primary socialization, gender identity and natural resources*

Gender refers to “socially-constructed differences between men and women; this is why difference in terms of sex is clear as long as it is biological” (Sabaté et al. 1995:14). Gender identity begins to form in the family, based on an individual’s physical sexual traits, and involves definition of what feminine and masculine is (Lamas 1996). This will cause a child to behave in a certain way and, once adult, to participate in culturally-determined gender-based division of labor (Lagarde 1993). On a daily basis, children internalize what Berger and Luckmann (1967) call “the generalized other” and eventually arrive at an abstraction of others’ roles and attitudes.

[...]the generalized other becomes an internalized model consistent with standards, from which his/her own conduct is observed and judged, the perspective that determines if s/he is content or discontent with him/herself (Frederick 1992:44).

During primary socialization children also learn about natural resources. By interacting with their congeners and natural environment (Berger & Luckmann 1967), children acquire knowledge about which natural resources to use for survival. The child↔natural environment relationship intervenes in family, community and cultural legacies. Individuals who view the world through a cultural lens transform nature into resources (Simmons 1982), thus facilitating a sustainable lifestyle that respects the identity of different people (Leff 1993, Myers 2008).

The concepts of nature and natural resources are closely related, although only some elements of nature are considered to be natural resources, i.e. physical riches or phenomena that meet human needs (Bassols 1986). Appropriation of nature in rural production processes is the material base for social reproduction and occurs in activities such as fishing, hunting, gathering, extraction, livestock and agriculture (Toledo 1994). Natural resources as a concept is characterized by the social use conferred them (Skinner 1974, Bassols 1986, Leff 1993, Méndez et al. 2008), and the knowledge acquired about them depends on the values, uses and practices of each society; in other words, all natural resources systems are culturally defined. This is why a resource such as prickly pear cactus (*Opuntia* sp.) is widely used in Mexico but under-utilized in other parts of Latin America; all its potential uses are not known in other regions (Leff 1993). The fundamental role played by socialization in the conception of the environment and natural resources is well known: “Each society has a relationship with the environment as a function of a particular ideology that exists within the culture that socializes its members” (Moran 1993:54).

### **Knowledge acquisition, transformation into capabilities or functioning, and cultural capital for individual, familiar and communal well-being**

#### *Knowledge, practice, abilities, attitudes and values*

Vygotsky’s constructivist theory, explains the teaching↔learning process as a dynamic relationship between two human beings in a physical and cultural environment (Vygotsky 1978, Coll 1997, Castorina et al. 2000). For Vygotsky, it is impossible to understand childhood development without an understanding of the culture in which it occurs because individual knowledge and the sociocultural medium are co-constructed.

It is related to the individual’s maturation processes since they actively reconstruct the medium’s influence. For sociocultural theory, the teaching↔learning process of human interrelations integrates those who learn with those who teach, creating the relationship between them (Castorina et al. 2000).

The capability approach is a theoretical tool that can be used for analysis, as a framework, and/or to monitor a situation (Tao 2010). It addresses areas including economy, education, modernization, inequality and morality as they are associated with the social freedom of choice, economic justice and citizen well-being (Sen 1999a, Flores-Crespo 2005, Legros 2010). Sen (1999a) defines a capability as a combination of attainments and functionings that indicate what a person can be, say and do to transform their rights into real freedom as has been used by Flores-Crespo (2005), Legros (2010). As it occurs in formal education, individuals acquire knowledge, abilities, attitudes and values during informal education, which they transform into capabilities to use in work, home, community and other ambits (Boud and Middleton 2003, Fuller et al. 2010, Tao 2010).

Based on sociological Theory of Cultural Capital, Bourdieu (1987), states that it is formed with knowledge plus the teaching↔learning process inside the family. In conjunction with

community interaction and participation (Castillo 2001a), this process helps individuals to acquire cultural capital (CC), which is expressed in three forms: (1) incorporated CC is personal, life-long learning such as the mother tongue, traditional festivities, understanding the role of the “generalized other”, and daily activities; (2) objectified CC consists of cultural goods expressed as instruments, machines, documents and tools; and (3) institutionalized CC is the education level and recognition thereof expressed in individual, non-transferable official scholastic degrees (Bourdieu 1987). Individuals incorporate and accumulate this capital, and can objectify it in their lives as cultural wealth. Its bases are built during primary socialization through existence in determined social and cultural spaces. Identifying and understanding how natural resources knowledge is acquired can shed light on regional management and conservation processes.

The interaction between natural and psycho-sociocultural environments as seen from different theories, concepts and variables, and from the perspective of those involved, can help us to explain the construction of social reality in relation to natural resources management.

We generated a scheme based on the theoretical approaches, concepts and actors that explain the interactions between participants (fathers, mothers and their children) described in the study. New questions then arise based on existing theories, or from a problem of practical interest, such as the one addressed here in our study, which can contribute to the understanding of the overall nature of the proposed problem. Addressing it from a different angle, it would result in a partial and fragmented view of the studied reality (Figure 1 in the article).

Applying this scheme, we analyzed participants’ appropriation of natural resources through productive processes (e.g. fishing, salt extraction, cutting mangrove, coconut cultivation, horticulture, raising livestock, conservation and ecotourism) in complex social behavior. Similar participation has been reported in a general study of community participation in Yucatan (Castillo 2001a, Castillo et al. 2008), and a case study of participant construction of social networks through concerned actions in natural protected areas in Catalonia, Spain (Calvet-Mir 2015). In another study, a social organization process was found to influence natural resources appropriation in the form of the exchange of medicinal plant species in home-gardens in the Amazon (Díaz-Reviriego et al. 2016).