Criticisms of the way ethnoscience was practiced biology essay

Science, Biology

Ethnoscience / EthnographyEthnoscience in the early 1960s provides a prototypical case of an elite specialty (Murray, 2006). (Rist and Dahdouh-Guebas, 2006) understand Ethnoscience according to (Atran, 1991) as " a scientific realm which aims to understand how humans––in spite of their fragmented and limited interactions with the world––are developing different forms of knowledge and beliefs". (Meehan, 1980) refers to Ethnosciences as the set of concepts, prepositions, and theories that are unique to each particular culture group in the world. (Rist and Dahdouh-Guebas, 2006) argue that Ethnobiology, that is often almost identical with what is defined as Ethnoecology, is one of the most prominent fields of Ethnoscience. (Benthall, 1993) defines Ethnobiology as a new branch of science that brings together two important areas of human knowledge––ethnology, the study of cultures, and biology, the study of life. Ethnoecology is defined quite similarly by (Gragson and Blount, 1999) as the study of the interactions between organisms (plants, animals, biodiversity) and the physical, biological and human factors to which they are related.(Conklin, 1954), the founding father of Ethnoscience, argued against the commonly held view that swidden agriculture (a temporary agricultural plot formed by cutting back and burning off vegetative cover) was irrational, economically unproductive, and an example of 'backward' agriculture. Using Ethnoscience to understand farmers' attitudes towards their environment, Conklin was able to explain the rationale behind swidden systems and demonstrate that they were in fact quite rational systems. Ethnoscience has been used by many different disciplines; thus there are studies in Ethnobotany, Ethnopedology, Ethnoforestry, Ethnoveterinary medicine, and Ethnoecology

(Mazzucato, 1996). Linguistic anthropologist Kenneth Pike created the terms Etic and Emic, which were derived from an analogy with the terms " phonemic" and " phonetic". Etic categories involve a classification according to some external system of analysis considered as appropriate by science. This is the approach of biology where the Linnaean classification system is used to define new species. It assumes that ultimately, there is an objective that is seen to be more important than cultural perceptions of it. In contrast, emic categories involve a classification according to the way in which members of a society perceive and classify their own world (Escalada and Heong, 2012). Emic methods attempt to describe a culture from the native's point of view. The goal is a description from within, articulation of the beliefs around the world and culture which are used by the native. Moreover, an emic orientation suggests that research be conducted with particular individuals, focusing on their unique, individual " insider" viewpoints (Morey and Luthans, 1984). After the first flurry of successes at discovering folk classifications by various eliciting techniques, few major advances have been made in the direction of a better understanding of lexical / semantic fields (Werner, 1972). One way anthropologists elicit indigenous criteria is through cognitive anthropology, or Ethnoscience, which was developed during the 1960s. Cognitive anthropology is the " study of people's perceptions of their surroundings as reflected in their use of language". The nomenclatures that ensue reflect categories that are created based on native's criteria of interest (Mazzucato, 1996). One of the criticisms of the way Ethnoscience was practiced earlier is that it didn't recognize the creativity of humans and the role of human choice or will over the environment. (Roy, 2004) states that " the problem with the sociology and cultural history of science is not so much that it claims that scientists are creatures of their particular social and cultural circumstances, but that it does not go beyond this to examine the similar cross-cultural cognitive practices within which science might be embedded. To say that something is socially constructed is not to say that it is inaccurate, only that people learn what they do (their ‘ social constructions’) from each other". An example is the fact that farmers dealing with comparable difficulties in different part of the World are likely to come up with similar solutions because they have developed basically the same dynamic understandings of the relationship between elements in an agroecological system (Roy, 2004). Another drawback of Ethnoscience was the problem of either…Or…. This means that a methodological approach to indigenous knowledge was supposed to use either an outsider approach or an insider approach, but not both. Moreover, an insider approach was synonym of a qualitative, social approach, leading ultimately to subjective results whereas the outsider approach, judged as more objective and scientific, could be characterized of quantitative and the results scientifically analyzed. An insider's perspective of science would take the view of the native participant in research whereas the outsider's orientation would take the nonparticipant " scientific" researcher's view (Morey and Luthans, 1984). In other words, the two approaches were considered as mutually exclusive. In the rare cases when they were combined, most of the forms of ethnography, especially those based on or influenced by " Ethnoscience" were devoted almost exclusively to the listing, sorting, and interpretation of such " folk" terms (Hammersley and Atkinson, 2007). More recent development recognizes that the insider's viewpoints must later be translated into outsider's categories for purposes of nomothetic analysis and generalizations (Morey and Luthans, 1984).(Mazzucato, 1996) states that another one of the criticism of Ethnoscience is that it assumes that language is the most important representation of values, an assumption that has been questioned by various scholars (Atran, 1993). An additional criticism is the long time required for an efficient in-depth work; otherwise it may produce only subjective results from the " Western" researcher point of view through local interprettaions of deducted categories. Nonetheless, if carefully done, this could be a useful component within a wider analysis. To counteract these criticisms, researchers should continue to work with the communities they survey for the purpose of their research. That will allow them to establish a climate of trust with farmers, and to undertake a more accurate in-depth study of farmers' management practices. Indeed, Ethnography, while using folk types, attempts to do more than simply document their meaning. They are taken as evidence of knowledge, belief, and actions that can be located within more general institutional contexts and analytic frameworks (Hammersley and Atkinson, 2007). Recent development in ways of practicing Ethnoscience are helping to correct the notion that indigenous knowledge only represents a collection of local knowledge generated by empirical body of experiences that cannot be related to current tendencies of global change. The claim for a better relationship between scientific and traditional " local" knowledge is important for a sustainable resource management, especially with the growing acceptance that sustainable development may be based on local forms of knowledge originally developed outside conventional sciences (Rist and Dahdouh-Guebas, 2006). Knowledge of local people does hold notions of ‘ globality’ which are based on their own cultural background. The relationship between different forms of knowledge is based on respect, complementarity and cooperation, instead of competition and hegemony (Rist and Dahdouh-Guebas, 2006). There is no doubt also that historically ‘ Western’ biological science emerged as a special purpose knowledge in a very specific context of use, with a specific division of labor, and like other local knowledge has simply reflected the interests of a particular local culture, that of scientists, who work as a community within social organizations and according to shared social norms (Roy, 2004).

Traditional Ecological Knowledge (TEK) or Indigenous Knowledge (IK)Traditional Ecological Knowledge (TEK) has been defined by (Huntington, 2000) as the knowledge and insights acquired through extensive observation of an area or a species. Indigenous knowledge, also referred synonymously as traditional and local knowledge, is used to differentiate the knowledge developed by a given community from the knowledge generated through universities, government research centers, and private industry (the international system, sometimes called the Western System). Indigenous knowledge refers to the knowledge of indigenous peoples as well as other defined communities (Warren, 1992). (Grenier, 1998) defines Indigenous Knowledge as the unique, traditional, local knowledge existing within and developed around the specific conditions of women and men indigenous to a particular geographic area, and which enables them to get the most out of their natural environment. Most of this knowledge and skills have been inherited from earlier generations. However, as they mature, individual men and women in each generation supply new information and ideas to this body of knowledge as a way to come up with survival strategies in this ever changing circumstances and environmental conditions.(Grenier, 1998) argues that the development of IK systems that cover all aspects of life, including management of natural environment, has been a matter of survival to the peoples who generated these systems. Such knowledge systems are cumulative, representing generations of experiences, careful observations, and trial-and-error experiments. The author also mentions that the IK systems are dynamic, continuously evolving with addition of new knowledge, innovations from within, internalization, use and adaptation of external knowledge to suit the local situation. Working with communities in order to elicit IK in the case of program of conservation of plant genetic resources for example, could mean working with farmers regarding the local classification and quantification, the agricultural techniques / systems, or the learning systems (Grenier, 1998). The definitions or classification of the local fauna, flora or phenomena, or indigenous methods of counting and quantifying could be unique to a particular community. Moreover, the seed practices, the seed network exchanges, the farming and cropping systems, the food processing techniques, the indigenous methods of imparting knowledge, etc. are all an integrated body of knowledge belonging to communities (Grenier, 1998). This body of knowledge has been working for centuries for farmers, especially in developing countries. Even though, they seem to produce merely enough to satisfy their own daily needs, the IK systems put in place and transferred from generations to generations have allowed them to build a resilience and adaptation to their system. Unfortunately, these IK systems are eroding every day. This situation is due to several causes. Among them, naturally, some IK is lost because techniques and tools are modified or fall out of use. Nonetheless, the majority of IK erosion can be attributed to pressures related to rapid modernization and cultural homogenization such as rapid population growth, growth of international markets, educational systems, environmental degradation, and development processes (Gepts, 2006, Grenier, 1998).(Barry et al., 2007c) when studying the varietal diversity of rice in Maritime Guinea discovered that the naming of different varieties of rice were based both on morphological traits (seed format and color, tillering capacity, leaf color) and adaptation to rice growing environments (mangrove, deep water, ground water, and upland). For that reason, the varieties with the best name consistency were the ones with marked morphological features. (Fukuoka et al., 2006) in their study of the phenotypic profiles of Vietnamese rice landraces populations, advocate that even though selection by farmers lead to a small phenotypic variation in agronomic characters, the targeting of several farms with different phenotypic profiles contribute to the conservation of regional genetic diversity of the landraces of rice. (Ram et al., 2007) suggest that various landraces might be used as parents in breeding new farmer-preferred varieties. (Gepts, 2006) underlies the fact that farmers, through farming practices such as time of planting, weeding, thinning and seed selection, are able to keep landraces adapted to their growing conditions and socio-cultural preferences. (Barnaud et al., 2007) contend that farmer's practices are important to the maintenance, despite gene flow, of landraces with different combinations of agronomically and ecologically pertinent traits, and therefore, must be taken into account in strategies of conservation and use of genetic resources. In-situ conservation of genetic resourcesIn situ conservation of agricultural biodiversity is the maintenance of the diversity present in and among populations of the many species used directly in agriculture or used as sources of genes in the habitats where such diversity arises and continues to grow (Brown, 1999). (Qualset et al., 1997) define in situ conservation as " the maintenance of variable populations in their natural or farming environment, within the community of which they form a part, allowing the natural processes of evolution to take place". Information about traditional knowledge accompanying local genetic resources, is an important element in in situ conservation for successful local programs (Brookfield et al., 2002, Salick et al., 1997). IK should be taken into considerations in conservation programs to increase the chances of gathering the majority of biodiversity available now for ex-situ conservation, and promote the in-situ conservation of unique genetic resources. Humans, like plants and animals are not static; they evolve, diversify, mate and give rise to a unique diversity that exhibits a highest variation when coming from the cross of different breeds. (Barry et al., 2007b) showed that in Maritime Guinea, the fact that Oryza glaberrima (African rice) and O. sativa (Asian rice) are grown together on farmers' fields, has given rise to a unique genetic diversity that need to be studied in-depth in order to better preserve it. The communities that use these resources and the knowledge they gathered about their environment for centuries have also to be taken into account when promoting the in situ conservation of resources. Communities interact with their environment, and among themselves, and try to find the best way to make use of their resources, especially in environments where traditional farming still prevails. They develop interactions and knowledge about crop uses, seed origins, and uses of different products from an individual crop species, market demands, agricultural systems, consumption, production conditions, risk factors, and social organizations that can all have an impact on the management of their resources. These interactions lead to phenomena that cannot be explained only by biotic factors. Numerous studies have shown the importance of IK in the preservation of natural resources, especially in situ plant genetic resources. (Brush and Meng, 1998) argue that a wheat farmer in Turkey may have different types of wheat for different usages and milieus. Farmers choose their wheat types depending on hillside or valley bottom areas, irrigated and rainfed parcels, homemade bread and urban grain markets, straw and animal feeding. (Deu et al., 2008) highlighted the fact that human factors, through the interactions between societies, geographical regions and sorghum botanical races, and the patterns of seed exchanges between farmers, explain a larger share of the observed genetic structure of in situ sorghum germplasm than do the climatic conditions. In fact, farmers rely on diversity of other farms and communities to provide new seed when crops fail or seed is lost or to renew seed that no longer meets the farmer’s criteria for adequate seed (Louette et al., 1997). (Brush, 1999) suggested that ethnic and social factors are key information to implement in situ conservation programs and conduct further ex situ collections of sorghum in sub-Saharan Africa. (Baco et al., 2007) found that the diversity of yam in Northern Benin (West Africa) was dependent upon several factors such as the level of cultural diversity of a village. Indeed, the high levels of diversity were found in the villages having the highest level of cultural diversity. Moreover, in spite of similar environmental conditions, the ethnic groups cultivate different cultivars and use farming techniques in connection with their traditions. An example of that is the fact that an ethnic group prefer small tubers adapted to produce easily marketable dried yams, another one is rather fond of yam with big tubers and the third group of medium-sized tubers. They hypothesized that in the third group, that includes two different ethnic groups who were growing analogous varieties of yam, the high level of similarity might be due to the fact that one ethnic group was, some time ago, slave of the other one. Hence, the slave ethnic group mimicked the master by lack of cultural references. The goal of in situ conservation is to encourage the continuous selection and management of local crop populations that embody not only diverse alleles and genotypes but also evolutionary processes such as gene flow between populations and local knowledge systems such as folk taxonomies and information about selection in heterogeneous environments (Brush, 1999). The success of in situ conservation is not only dependent upon the number of alleles or genotypes preserved. It might also be measured by the number of farmers within a target area or group who maintain local crop populations and manage those populations according to local criteria and practices (Brush, 1999). (Alvarez et al., 2005) demonstrated that in a village of Cameroun, farmers who grow sorghum have put in place a singular system of seed exchange. The fields of older farmers, larger and containing a greater number of varieties, act as sources, whereas fields of younger farmers act as sinks, becoming sources as their owners mature.

Natural factors (environmental pressures and biological traits) and human management are inextricably linked and jointly shape the genetic diversity of crop plant populations (Alvarez et al., 2005). Human management modifies both selection pressures and population structure, thereby affecting drift, migration, and metapopulation dynamics (Jarvis and Hodgkin, 1999). Farmers make many kinds of decisions all through the chain of agricultural operations that affect genetics of crop plants (Alvarez et al., 2005) and sustainable conservation of in situ genetic resources. Centers of origin and AfricaAgriculture arose independently at several locations across the World, beginning about 12, 000 years ago (Hancock, 2004). In his landmark work on cultivated plants, (Vavilov, 1926) used the centers of diversity of native crop species to predict where their center of origin, thus where they were initially domesticated. Vavilov originally identified eight centers of domestication (Vavilov, 1926), based primarily on patterns of crop diversity, from which all the major crops were domesticated. He concluded that each crop had a typical primary center of diversity that was also its center of origin. The center of origin is the birthplace of a particular taxon (Brown and Lomolino, 1998). A center can also be considered as " an area where things originate and out of which things are dispersed" (Harlan, 1971). Subsequent works have demonstrated the flaws in Vavilov’s theory of center of origin and center of diversity. One of the main problems with his argument was that his theory could not be applied to all crops. Wheat, sorghum, pearl millet and beans for example do not have a true center of diversity whereas other crops like barley and rice were domesticated far from their centers of diversity (Harlan, 1992). The problem is that center of greatest diversity and center of origin are not always the same; they do not always overlap (Hancock, 2004, Harlan, 1971). (Zhukovsky, 1968) reviewed Vavilov's centers and enlarged them in order to account for the evidence. However, the problem persists because he just expanded the centers to megacenters, and implicitly admitted that they were no centers at all (Harlan, 1971). To overcome this criticism, Vavilov developed the concept of secondary centers to describe those cases where centers of diversity and centers of origin are not the same. This approach helps with several crops, including wheat, barley and rice, but there are still a number of crop species that appear to have been domesticated completely outside their native ranges as a result of several causes such as long-range oceanic drift, dispersal by migratory birds, human trade of wild material, or original movement as a weed (Hancock, 2004). The main criticism for the single center of origin for Africa identified by Vavilov and confined in Ethiopia is that it does not account for all the other crops domesticated throughout Africa, especially along the belt located south of the Sahara and north of the equator, going from Cape Verde to the Horn. In fact, the African center has few meaningful dates for the time of agriculture there, but generally, that time appears to be relatively late. There were, however, in the vast zone from Cape Verde to Abyssinia, a considerable number of plants domesticated and some of them are major plants (Carter, 1997). For example, Digitaria exilis (fonio) is believed to have a probable area of domestication located from Senegal to Cameroun (Harlan, 1971). The primary center of diversity for O. glaberrima, probably formed around 1500 BC, is believed to be the swampy basin of the upper Niger River, while the two secondary centers formed 500 years later to the southwest near the

Guinean Coast (Portères, 1962, Portères, 1976). Upland types were developed and rice became the staple for the tribes from the Bandama River in the central Ivory Coast westward through Liberia, Sierra Leone, Guinea, and Senegal. The culture of African rice also spread eastward across the savanna of Ghana, Togo, Dahomey, and Nigeria to the Lagone region of Chad (Harlan et al., 1976). Sorghum bicolor (sorghum) and Dioscorea rotundata (yam) have as putative area of domestication respectively, the broad-leaved savanna, Sudan, Chad, and the area from Ivory Coast to Cameroun. All these areas of domestication have not been taken into account by Vavilov in the center of origin of crop species he identified in Ethiopia. Moreover, (Harlan, 1971) expresses the idea that an area that covers a range of more than 7, 000 kilometers can merely be called a " center". The eight centers of domestication identified by Vavilov were modified by (Harlan, 1971) to include space, time and variation. He used a combination of archaeological evidence of wild progenitors of current cultivated crop species and of evidence of early practice of agriculture with the native ranges of crop progenitors. He identified three systems composed of a center of origin and a noncenter (larger, diffuse areas where domestication is thought to have occurred), in which activities of domestication were dispersed over a span of 5, 000 to 10, 000 kilometers. The three systems include: a Near East center and a noncenter in Africa, a North Chinese center and a noncenter in Southeast Asia and the South Pacific, and a Mesoamerican center and a South American non-center. Harlan suggests that there has been in each system an interaction between the center and the noncenter.(Harlan, 1971) classified domestication patterns into five classes: Endemic: the domesticant occupies a well defined, small geographical region (guinea millet)Semi-endemic: the domesticant occupies a small range with some dispersal out of it (African rice and teff)Monocentric: the domesticant has a wide distribution with a discernible center of origin (coffee, rubber, cacao, and oil palm)Oligocentric: the domesticant has a wide distribution and two or more centers of diversity (wheat, barley, pea, lentil, maize, lima bean, etc.)Non-centric: domesticant has a wide distribution, but no discernible centers of diversity (American beans, radish, sorghum, pearl millet, etc.). Ethiopia provided the World with coffee but also a unique assemblage of endemic crops, including the cereal teff, the oil crop noog, enset (Harlan, 1992). Teff is a staple food for millions of Ethiopians. It is a royal, if not actually sacred, grain and is planted on more acreage than other crop on Ethiopia. Even though it is not used elsewhere to any appreciable extent, to Ethiopians this is basic to life (Harlan et al., 1976). People throughout the World have utilized thousands of plant species, but very few of them have attracted widespread attention (Hancock, 2004). The question of the existence of a geographical " center" of origin and domestication of crop species remains. The current belief is that crops did not necessarily originate in centers, nor did agriculture necessarily develop in a geographical " center" (Harlan, 1971). Particularly in Africa, even if the time range of domestication remains to be determined by archaeological research, there is still a lack of evidence for a center in which agriculture originated and the process of domestication began or ended, nor there is evidence for the kind of center described by Vavilov in which dozens of crop originated (Harlan, 1971). Harlan suggests the establishment of a center for one crop at a time.

Thus, it might be better to consider the model of regional and/or multiple areas of origin rather than the idea of a localized, unique origin for many crops. LandracesIn traditional farming systems, biological and human factors interact to shape evolutionary forces (Jarvis and Hodgkin, 1999). Biological factors comprise both environmental pressures and biological traits of the plant, such as its mating system. Human factors affect the dynamics of diversity in many ways, acting on gene flow, drift and selection (Barnaud et al., 2008b). (Harlan, 1972) speaks of landraces as the legacy of past cultivators to the new generations. He also states that landraces are " variable, in equilibrium with both environment and pathogens, and genetically dynamic". In fact, landraces are: Variable: numerous landraces are generally cultivated on farmers' fields. Authors have demonstrated that farmers in the village of Duupa in Cameroun cultivate on their numerous farms, landraces at the same time as improved cultivars, favoring extensive pollen flow and giving rise to a high outcrossing rate in the farmers' fields (Barnaud et al., 2007, Barnaud et al., 2008b, Barnaud et al., 2008a, Barnaud et al., 2009). In equilibrium with both environment and pathogens: Landraces are reliable, dependable. Even under low care and maintenance, farmers can expect to have a decent yield. They are adapted to their environment because they have developed traits that enable them to survive in their growing environment. In fact, they underwent several rounds of selection (natural and human-induced) that made them adjusted to their milieus. They have developed phenotypic traits that have evolved to help them cope with their environmental challenges or increase their mating success (Conner and Hartl, 2004). Domestication often resulted in reduced levels of variability, but hybridization between crops and their wild progenitors occasionally increased their local adaptations and expanded their geographical range (Hancock, 2004). Genetically dynamic: It is believed that hybridizations between sexually propagated crops (like rice) and their wild progenitors could have occasionally increased their variability and improved local adaptations (Hancock, 2004). Introgression between crops and wild relatives provides a broadened genetic base for natural and human selection (Jarvis and Hodgkin, 1999). Indeed, it has been demonstrated that wild relatives, landraces and/or modern varieties of rice coexist and naturally interbreed, giving rise to hybrids. Particularly in Africa, Asian rice and African rice are often grown together in farmer’s fields (Barry et al., 2007b, Nuijten et al., 2009, Semon et al., 2005). Most of the rice grown in western Africa today is Asian rice, which has largely replaced the ancient traditional African rice. The progenitor of African rice is Oryza barthii, a savannah plant. It is an annual, an excellent seeder, and is adapted to ephemeral water holes that dry up in the dry season. Not uncommonly it is found in association with its perennial relative Oryza longistaminata, but the latter requires a more secure water supply. Both are harvested in the wild today, although O. longistaminata is a poor seeder and does not contribute very much (Harlan, 1977). (Brush, 1999) states that ecological relationships such as gene flow between different populations and species, adaptation and selection to predation and disease, and human selection and management of diverse crop resources are components of a common crop evolutionary system that generate crop genetic resources. Landraces are adapted to their environments but are in constant variation. They are under continuous human selection. Humans deliberately or not cultivate them, they are not the product of modern plant breeding or subject to purifying selection (Brown, 1999). Moreover, farmers plant a diverse assemblage of genotypes to lower the risk of failure and increase food security, especially in systems where farmers have limited capacity to control spatial and temporal environmental variability with material inputs (Alvarez et al., 2005). For the on-farm conservation of domesticated species, the traditional cultures and cropping systems that grow and use such populations are fundamental aspects of the habitats to which they are adapted. The systems shape their present genetic structure and determine the changes within landrace populations. Hence, farmers are crucial partners in the process of in situ conservation (Brown, 1999). (Alvarez et al., 2005) demonstrated that in a village of Cameroun, farmers who grow sorghum have put in place a singular system of seed exchange. The fields of older farmers, larger and containing a greater number of varieties, act as sources, whereas fields of younger farmers act as sinks, becoming sources as their owners mature. Genetic bottlenecks that arise with the small number of genitor within each fields may be counteracted with this system. Natural factors (environmental pressures and biological traits) and human management are inextricably linked and jointly shape the genetic diversity of crop plant populations (Alvarez et al., 2005). Human management modifies both selection pressures and population structure, thereby affecting drift, migration, and metapopulation dynamics (Jarvis and Hodgkin, 1999). Farmers make many kinds of decisions all through the chain of agricultural operations that affect genetics of crop plants (Alvarez et al., 2005). Moreover, traditional farming systems exhibit two significant features: a high degree of vegetational diversity (biodiversity) and a complex system of indigenous technical knowledge (Ethnoscience) (Altieri, 1993). Both elements are obviously highly interrelated since the maintenance of biodiversity is dependent upon local farmers' knowledge about the environment, plants, soils and ecological processes (Toledo et al., 1985). (Zeven, 1998) proposed that landraces could be classified into two distinct groups: " autochthonous landrace" and " allochthonous landrace". The former, which is the most common type, includes landrace that has been grown since long period in the farming system studied and has adapted itself to the always changing growing environment conditions and the introduction of genotypes of other landrace(s) or cultivar(s). The latter would be a rare type of landrace introduced recently in the system concerned from foreign region(s). This type will be contaminated as well, either by the autochthonous landrace or by the introduction of improved germplasm. Harlan’s definition fits perfectly rice landraces in Africa as they are cultivated currently. They undergo numerous pressures not only from their environment but also from farmers who select them, consciously or not. To this definition, two important features should be added: the human selection aspect and the constant evolution of these landraces. These two traits are important in the establishment of landraces and in the in situ conservation. Indeed, as (Brush, 1999) mentions so well, " in situ conservation is meant to maintain a living and ever-changing system, thus allowing for both loss and addition of elements of the agroecosystem". Problem statement and rationaleTransitioning from subsistence agriculture to a more developed agriculture is possible only through the enhancement of the qualities of local cultivars in collaboration with farmers who will intervene through the process, especially in the selection of valuable traits. Farmers are skilled at preserving genetic diversity within and among varieties. They also excel at keeping landraces adapted to their growing surroundings and socio-cultural preferences (Gepts, 2006). For instance, farmers in western Rajasthan have been known to produce and maintain their landrace population of pearl millet through their own distinct seed management practices that integrates traditional and conventional germplasm (Vom Brocke et al., 2002). Farmers in Mexico allow teosinte to remain within or near their maize fields to favor wind pollination and occurrence of natural crosses (Wilkes 1877 quoted in (Altieri and Merrick, 1987). The role of science and technology in this process can be accomplished through the input of an array of solutions adapted to specific milieus structured according to particular socio-economic, cultural, political and environmental factors. These solutions will come from interdisciplinary studies that are of particular interest for each country and targeted to answer specific questions in the context of climate change, global warming and other phenomena the World faces today. However, for the effective success of such programs, the country has to identify and understand the genetic resources housed within its boundaries and prioritize and conserve unique biodiversity to promote their sustainable use and management. The conservation of genetic resources can be done through ex situ (off-site) and in situ (on-site) conservation techniques. According to the Food and Agriculture Organization of the United Nations (FAO) estimates, approximately 1500 gene banks maintain 5. 5 million samples collected throughout various geographic regions of the World (Gepts, 2006). The inclusion of in situ conservation fits in with the emphasis currently placed on the long-term sustainability of production systems and protection of the natural resource base (Hawtin and Collins, 1998). It is now widely recognized that ex situ and in situ approaches are complementary and should be jointly included in conservation strategies (Barry et al., 2007c). In sub-Saharan Africa, like in many other parts of the World, traditional farming methods such as the small-scale polycultural systems help maximize agricultural biodiversity or agrobiodiversity (Altieri and Merrick, 1987, Brush, 1995, Thrupp, 2000). Cultural diversity and local knowledge specific to agricultural communities are often thought to expand the farming practices, favoring therefore an enhancement of agrobiodiversity. Among those practices is the use of " folk varieties", also known as landraces (Thrupp, 2000). They can be defined as varieties that have evolved under continuous natural and farmers' selection practices in farmers' fields (Harlan, 1972) and today they represent an important source of novel alleles for crop improvement. Moreover, local knowledge and culture, considered as integral parts of agricultural biodiversity, shape through selection the amount of diversity that is actively managed at the farmers' field level, and therefore at a more regional level. Farmers use inter and intraspecific varietal diversity to cope with uncertain and heterogeneous farming conditions (Bellon, 1996a). Therefore, this selection, combined with the natural selection and introgression that occur in farmers' field, led to the development of thousands of varieties, especially landraces, adapted to diverse agro-ecosystems and managed by farmers. However, outside of the communities concerned, there is a lack of knowledge about the amount and distribution of this varietal diversity. In heterogeneous environments and poorer nations of the World, the genetic diversity sowed for food and fodder as well as the next season's seed still represent the main dependable source for farmers (Joshi and Bauer, 2007). The concern that the replacement of landraces by modern varieties, which implies a loss of (potentially valuable) genetic variation, has stimulated an extensive effort to sample and store landraces in ex situ genebanks (Frankel, 1970), (Harlan, 1972), (Hawkes, 1983). The concept of on-farm in situ conservation has also been recognized as an important technique of conservation of genetic resources (Barry et al., 2007b, Gyasi et al., 2004, Maxted et al., 1997). The field of Plant Genetic Resources (PGRs) conservation will have to address how to best combine traditional knowledge, technological advances in the areas of molecular genetics, genomics, cryopreservation and other conservation techniques, and utilization of GIS, to further assist the sustainable use of these resources (Gepts, 2006). This is definitely the domain to which the present research is contributing. Diversity at the phenotypic levelRice is one of the crops with a long history of development in cultivation techniques. Rice is the world's single most important crop under cultivation since it is the only major cereal crop that is consumed almost exclusively by humans (Khush, 1997). Rice is a primary food source for about half of the world's population (Zeigler and Barclay, 2008) and is a staple food when it comes to humans daily caloric intake. The genus Oryza contains 22 species: two are cultivated (Oryza sativa and Oryza glaberrima) and 20 are wild. Native to sub-Saharan Africa, the domestication of O. glaberrima is considered to have occurred, from peoples living at the bend of Niger River, 2, 000-3, 000 years ago from the wild ancestor Oryza barthii (Portères, 1976, Portères, 1962). It is endemic and only cultivated in tropical West Africa (Ghesquière et al., 1997). The primary centre of diversity of O. glaberrima is the swampy basin of the upper Niger (OECD, 1999). O. sativa is cultivated worldwide, and the word " rice" generally indicates a plant and a crop of this species (OECD, 1999). " For most of the world, rice connotes Asia and the vast agriculture of far Eastern river deltas…but rice is also African…" (National Research Council 1996). Oryza glaberrima is a local cultivar with its wild ancestors available throughout West Africa. O. glaberrima is being replaced everywhere in West Africa by the Asian species (Portères, 1962) and more recently by their cross, NERICA® (Linares, 2002, Kijima et al., 2006). An in situ conservation strategy is now urgent, since the co-cultivation of indigenous Oryza glaberrima with Asian Oryza sativa has likely given rise to a unique genetic diversity (Barry et al., 2007b, Semon et al., 2005). To develop a successful genetic conservation program of rice in West Africa, it is critical to identify and understand the genetic resources housed within its boundaries and prioritize and conserve unique biodiversity to promote their sustainable use and management. African rice (Oryza glaberrima) provides a unique and exceptional research organism because it is a local cultivar with its wild ancestors available throughout West Africa. O. glaberrima is an example of Underutilized Plant Species (UPS) in the sense that it is one of " those plant with under-exploited potential for contributing to food security, health, income generation and environmental services" (Dawson et al., 2009). Even though O. glaberrima has many exploitable traits and is being cultivated for many generations in its endemic center of origin, it is being replaced everywhere in West Africa by the Asian species (Portères, 1962) and more recently (since 2005) by their cross, NERICA® (Kijima et al., 2006, Linares, 2002). Farmers have been taking advantage of various traits associated with indigenous rice for centuries. However, very little is known about the genetic diversity of African rice landraces and cultivation practices of African rice growers, especially in Benin. It is fundamental to understand the underlying mechanisms that are responsible for the current amount of native genetic diversity, and the impact of introduced germplasm on this diversity. African rice, Oryza glaberrima, is traditionally found in a variety of West African agro-ecosystems although it is largely abandoned in favor of high yielding O. sativa cultivars due to its poor agronomic performance (Semagn et al., 2006). O. glaberrima occupies a wide range of ecosystems in regard to water supply: from rainfed hill slopes to deep water conditions and coastal mangroves (Ghesquière et al., 1997). O. glaberrima has many unique traits such as weed competitiveness, drought tolerance, ability to grow under low input conditions (Sarla and Mallikarjuna, 2005), moderate to high level of resistance to blast (Silué & Notteghem 1991), resistance to nematodes (Reversat and Destombes, 1998), good level of tolerance to abiotic stresses such as acidity, and iron toxicity (Jones et al., 1994). This suite of agronomically important traits characterize the African farming context by illustrating the types of features and environments in which farmers traditionally select rice for cultivation (AfricaRice, 2006). Hence, farmers usually select seeds based on morphological features that are of interests for them to suit different growing environments. Local knowledge and culture, considered as integral parts of agricultural biodiversity, shape through selection the amount of diversity that is actively managed at the farmers' field level, and therefore at a more regional level. Farmers use intraspecific varietal diversity to cope with uncertain and heterogeneous farming conditions (Bellon, 1996b). Therefore, this selection, combined with the natural selection and introgression that occur in farmers' field, led to the development of thousands of varieties, especially landraces, adapted to diverse agro-ecosystems and managed by farmers. However, outside of the communities concerned, there is a lack of knowledge about the amount and distribution of the varietal diversity. Since phenotypic characters of plants are the targets of selection and their levels of diversity may vary, they are used in the estimation of the variation between and within crop populations. In addition, important or desirable traits of interest for plant breeders are usually revealed through the evaluation of phenotypic diversity (Singh, 1989). Moreover, studies at the phenotypic and genetic level have been used to understand the variability of species within and between geographical regions, and discover or re-class species. The first step towards these studies is the collection of germplasm, as part of acquisition. Accessions (seeds, roots, tubers, etc.) from different species or populations are usually gathered from exploration of known genetic diversity areas for plant species such as farmers' fields, market places, wild habitats, etc. (Rao and Iwanaga, 1997). Diversity at the molecular levelAlthough molecular data cannot always be relied on for a distinct differentiation of species (King and Burke, 1999), many molecular markers have been developed since the discovery of their use in genetics. Molecular markers have been widely used to access the genetic diversity and relatedness of plant species (Gepts, 2006). They constitute a powerful tool to reveal, in contrast to morphological traits, differences among genotypes at the DNA level, offering a more dependable, direct and efficient tool for the characterization and conservation of germplasm (Ram et al., 2007). Evidence for the diversity within and among landraces, cultivars and wild species relatives have been found by various molecular techniques. These include RFLP (Restriction Fragment length Polymorphism) (Sun et al., 2001) with rice), RAPD (Random Amplified Polymorphic DNA) (Buso et al., 1998) with wild rice), AFLP (Amplified Fragment length Polymorphism) (Portis et al., 2006) with Italian pepper), (Adoukonou-Sagbadja et al., 2007) with fonio-millet), (Kiambi et al., 2010) with wild rice), Single Nucleotide Polymorphisms (SNPs) (Nasu et al., 2002) with rice), and Simple-Sequence Repeats (SSRs) or microsatellites markers (Zhang et al., 2006) with wheat, (Tiranti and Negri, 2007) with Phaseolus vulgaris, (Feng et al., 2006) with naked barley, (Barnaud et al., 2007, Barnaud et al., 2008b) with sorghum, (Kobayashi et al., 2006, Semagn et al., 2007), with rice). Examples of molecular markers used in research involving rice include among others (i) study of DNA polymorphism in landraces and cultivars of rice (Kobayashi et al., 2006, Yang et al., 1994); (ii) analysis of the genetic variability of wild rice populations (Buso et al., 1998, Kiambi et al., 2010); (iii) study of the ecogeographical distribution of rice genetic diversity as tool for assisting in in situ genetic resource conservation (Barry et al., 2007c); (iv) assessment of genetic relationship among NERICAs varieties (Semagn et al., 2007) or among traditional (landraces) and/or improved and/or wild species relatives germplasm(Sun et al., 2001, Ndjiondjop et al., 2006, Zhang et al., 2006, Thomson et al., 2009, Ram et al., 2007, Zeng et al., 2007). Microsatellites markers will be used in this study because they have been recognized as efficient as AFLP for estimating genetic diversity and gene pool classification of common bean, another commonly selfing species (Maras et al., 2008). In addition, they have been reported to be common in rice (Chen et al., 1997), to detect a significantly higher degree of polymorphism in rice (Yang et al., 1994) and to be suitable for accessing the genetic diversity among closely related rice cultivars (Ram et al., 2007, Yokozeki et al., 1997). Several studies have been undertaken in Benin to access the genetic diversity of species. (Assogbadjo et al., 2006) used molecular techniques to differentiate populations of Adansonia digitata in three ecogeographic regions in Benin whereas (Yorou et al., 2007, Yorou and Agerer, 2008) were able to determine three new species of fungi (Tomentella capitata, Tomentella brunneocystidia and Tomentella Africana) based on morphological and molecular analysis. However, (Gepts, 2006) contends that genetic resources conservation needs to move beyond its descriptive nature and inquire about a better understanding of the distribution of genetic diversity within and among accessions. For doing so, a better integration of developed and newly improved techniques (molecular genetics, cryopreservation, genomics, etc.), other conservation methods and Geographic Information Systems (GIS) is needed to best address how to integrate technological advances in order to ease the management and sustainable exploitation of these resources (Gepts, 2006). Diversity in spaceThe end of last century has seen the pairing of GIS with studies on genetic resources conservation (Gepts, 2006). In fact, GIS has been recognized as a powerful " tool for investigating the processes that shape genomes and for conserving and using genetic diversity as effectively and efficiently as possible (Jarvis et al., 2005b)". GIS is likely to highlight patterns in the spatial distribution of diversity values, and to discover simultaneousness's or relationships between genome characteristics and the properties of the environment. GIS is used to conduct ecogeographical survey for localization and selection of sites for seed collection in order to understand the distribution and to guarantee a representative sample of the existing genetic diversity (Draper et al., 2003). The ecogeographical approach synthesizes ecological, geographical and taxonomic information (Maxted et al., 1997) and will help to understand the geographical distribution of germplasm in space and time as well as the abiotic and biotic factors that affect levels of genetic diversity. Both environmental factors such as climate, land cover, topography, soils and anthropogenic factors such as habitat destruction and artificial selection help shape genetic patterns and structure in crops and related wild species (Jarvis et al., 2005b). Hence, the estimation of the impact of improved varieties by the use of GIS opens the way for a multidisciplinary approach in the field of PGR management facilitated by the GIS-based inquiries (Greene and Guarino, 1999). However, although the merits of previous studies of spatial analysis in PGR research at the species or gene-pool level in order to pinpoint regions of high species diversity or species distribution are recognized, it is imperative to have more studies undertaken at the genetic level now (Jarvis et al., 2005a). Thus, molecular markers, complemented by appropriate GIS software packages are powerful tools in mapping the geographical distribution of genetic variation and assessing its relationship with environmental variables (Adoukonou-Sagbadja et al., 2007, Kiambi et al., 2010). The present research plans to use molecular markers to access the diversity among rice landraces, wild crop relatives, and cultivars in Benin in order to identify areas likely to contain germplasm of interest. Research objectives, questions and hypothesesThe general area of the research is the field of crop evolution and Plant Genetic Resources (PGRs) conservation. The specific area in which this research is framed is the study of rice diversity and its association with environmental variables. While this type of research has been applied at different locations and for different species (Adoukonou-Sagbadja et al., 2007, Kiambi et al., 2010, Portis et al., 2006, Sanni et al., 2008), it has not been employed in Benin to look at the rice varietal diversity managed by farmers. The overall goal of the research is to assess the extent and spatial distribution and dynamics of the genetic diversity of African rice currently managed in traditional rice systems through the analysis of seed conservation patterns and to identify the strategies for an in-situ and ex-situ conservation of landraces. The relationship between the adoption of improved germplasm like NERICA® and the maintenance of germplasm diversity at the farmer level will also be investigated. Specifically, the aims of this study are threefold: Ethnography studyObjective: Determine the strategies of landrace conservation or germplasm management by farmersQuestion: What rice populations are present in the northern and southern upland rice growing environments in Benin, and in what proportion? Hypotheses: Landraces are the most prevalent taxonomic group of Rice in BeninWild populations are the least presentThe richness of landrace population is more associated to farmers’ ethnic group than to their geographical location. Landrace population may differ from one ethnic group to another within a given area but the same ethnic group surveyed at two different geographic locations will manage similar varieties. Molecular diversity and association with environmental variablesObjective: Map the genetic landscape of African rice at the farm, village and regional scaleQuestion: Where are the Rice populations located in rice growing environments in Benin? Hypotheses : Rice populations will cluster on the basis of geographic originThe more the number of populations in a sub-region, the higher the amount of diversity. Genetic diversity of cultivated rice is higher in the Southern regions than the Northern ones. Unique genetic diversity clusters will be more abundant in the Northern region. Rice populations will be associated with specific environmental characteristics such as rainfall and temperature. Rice populations will occur in relation with specific vegetation mosaics. Peak genetic diversity will occur in intermediate environmental variables areasConservation of rice varietal diversityObjective: Propose a comprehensive tool for an in situ conservation and utilization of rice populations in Benin in participation with farmers. Question: What are the specific conclusions regarding an ex-situ and in-situ conservation of rice varietal diversity that can be elaborated? Hypotheses:" Hot spots" of rice genetic diversity will be identified in the rice growing regions of the countryA systematic rather than opportunistic targeting of populations and areas for both ex-situ and in-situ conservation will be elaborated. This dissertation is organized in three main chapters, presenting three intertwined studies: ethnographic surveys of rice varietal diversity, genetic diversity of rice germplasm collected at the farmers’ level and ecogeography of the genetic diversity defined. Chapter 2 attempts to define the socio-economic, cultural and environmental factors that affect the management of rice varietal diversity in traditional rice farming systems in Benin. Chapter 3 argues that the genetic landscape in Benin consists of modern varieties, traditional varieties (landraces) and hybrids between O. sativa and O. glaberrima that are different from the NERICAs. The last chapter presents the ecogeographic distribution of the genetic diversity managed at the farmers' level.