Draft not for citation

The Impacts of Collective Action and Property Rights on Plant Genetic Resources

by

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Paper prepared for the CAPRi-IPGRI Workshop on Property Rights, Collective Action, and Local Conservation of Genetic Resources, 29th September-2nd October, 2003, Rome.

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Genetic resources in agriculture: a new research agenda on institutions and rights for sustainable management of agrobiodiversity and equitable sharing of benefits.

The term 'plant genetic resources' refers to genetically determined traits in useful plants that can be conserved, characterized, evaluated and used by people to meet essential needs. These resources are not simply the genes encoded in the DNA of useful plants, but are particular genetic expressions of the genes that have been recognized and selected. The term itself first became widely used to describe what plant breeders did, namely passing useful genetic traits between cultivators or wild relatives of a species through crossing to produce an improved variety of a crop." (Eyzaguirre, 2001). Plant genetic diversity is measurable at three levels: the combinations of species that contribute to an ecosystem, the number of different species present and the different combinations of genes in species-the different varieties.

Recent advances in molecular biology, genetics, and applied science in crop and livestock breeding and fisheries have made the use of genetic resources widespread and more valuable. The impact of genetic resources on agriculture has been dramatic. Since 1945 world crop yields have increased between two and four fold depending on the crop "and an estimated 20% to 40% of this increase has been achieved by genetic modifications and breeding. The introduction of new genes and genetic modifications through crossing existing crop varieties with wild relatives is valued at approximately US$115 billion per year world wide in crop yield increases…" (Pimentel et al. 1992, 1997).

Genetic diversity of crops and livestock also plays a key role in sustainable agricultural practices. Despite debates on the relationship between agricultural development and biodiversity conservation, there are numerous examples of genetic resource conservation and use that show how the loss of biodiversity can reduce food security, increase economic risk, thus threatening the viability and sustainability of agricultural systems particularly for poor farmers. Specific risks that result from the erosion of biodiversity include: increased vulnerability to insect pests and diseases, negative effects on nutrition by accelerating the decline in the variety of foods, reduction in possibilities for adaptation and use for future generations, and loss of local knowledge about diversity[1]. Together these factors and trends directly threaten the livelihood of rural communities and the food security and food quality for generations to come [2]. Economists consider crop genetic diversity as an impure public good, with intergenerational and interregional dimensions. While any individual plant seed has the physical characteristics of a private good, the germplasm contained in the seed itself, which is information, has the public goods characteristic of being "non-rival", meaning that information itself is not diminished by use of information. Maintaining crop diversity therefore produces a public good, with long lasting effects over generations.

Multiple property rights that affect the conservation and use of genetic resources

The global commitment to conserving agricultural biodiversity and promoting its sustainable management for development has focused attention on the fact that plant genetic resources are still actively managed as livelihood assets by the rural poor. Understanding how farmers gain access to these genetic resources, how they deploy, exchange and improve them has become a central question. Social, economic and institutional research on customs, rules and institutions like tenure and access regimes, and collective action has thus moved squarely into the field of genetic resources. Furthermore, as the value of genetic resources becomes more apparent, the number of

[1] The Central Role of Agricultural Biodiversity: Trends and Challenges in Conservation and Sustainable Use of Agricultural Biodiversity. A Sourcebook. UPWARD-IPGRI. Forthcoming.
[2] FAO State of the World's Plant Genetic Resources for Food and Agriculture Prepared for the 1996 Leipzig Conference.

actors and stakeholders has also grown. This multiplicity of actors is matched by the plurality of legal and institutional forms by which people gain access and mobilize to use and derive benefits from genetic resources.

Initial studies on the impact of intellectual property rights, traditional resource rights on local incentives and policies to maintain crop and animal diversity and develop new varieties and breeds have begun to explain how property rights affect forms of collective action and access regimes that influence the maintenance and conservation of genetic resources. These studies have also shown that more work is needed to show how multiple access, traditional tenure regimes, and informal institutions can be considered and mobilized for the conservation and development of genetic resources. The conservation of genetic resources is intimately linked to the benefits that people derive from their use; this obliges us to pay closer attention to the rules and institutions by which farmers and communities gain access to and channel benefits from genetic resources.

Genetic resources determine the usefulness and value of the biological assets that feed humankind and maintain the viability of the human environment; it is therefore not surprising that they have received global attention for those concerned with environment, human development, and food security. Plant genetic resources are uniquely different from other natural resources and thus have generated much debate over specific "*sui generis*"property rights and access regimes to govern their exchange, conservation and use (IPGRI 1997, Tuxill 1999). While *sui generis* approaches for property rights, access and exchange of genetic resources have helped focus global attention on the conservation of this strategic resource, the development and equity implications of the conservation and use of genetic resources have at times received only superficial if well-meaning attention.

Placing genetic resources squarely within a development and sustainable livelihoods context also places the study of property rights and access to genetic resources within the broader context of natural resources management by poor farmers. We are thus able to look at the fundamental ways that rights, institutions and collective can constrain or

facilitate the use of genetic resources for development and food security. In addition our analysis is more firmly grounded on a broad base of theoretical and empirical research on property rights and institutions for collective action (Ostrom. 1990; A. Poteete and E. Ostrom 2003; R.Meinzen-Dick and R. Pradhan 2002).

In general terms, property rights facilitate coordination and collective action among people and groups by assigning responsibilities that carry with them the expectation of a stream of benefits. They structure the institutional landscape at the village level, within cultural communities and at administrative levels and determine in what way and to what extent individuals coordinate to gain access and use greater or lesser diversity in genetic resources. Also, understanding the allocation and application of property rights is crucial for increase social benefits of target groups within society by promoting behavior that is socially optimal while discouraging socially negative investments. In economic terms, the "… function of property rights is that of guiding incentives to achieve a greater internalization of externalities (Demsetz, 1967: 348 in Baland and Platteau)."

Historically, property rights have promoted two types of conservation. First is the use of diverse crop varieties in small-holder agricultural systems (*in-situ* conservation) that depends in large measure on secure and defined tenure and access to plots within diverse landscapes, Second is the public regulation and restricted access to protected forest or wilderness reserves where wild crop relatives and non-timber forest products are found (living gene-banks). New conservation approaches are working towards the integration of private and public incentives by using property rights to legitimize usufruct and regulated use of gathered plants, wild-varieties and non-timber forest products, and to devolve enforcement, decision-making, and a sense of ownership to local community institutions **(**S.Laird, 2001).[3] In each case, property rights applications have a different impact on the distribution of plant diversity. Property rights also influence the performance of social

[3] There are many examples of community based management of natural resources which have been effective in maintaining habitat and forests. The CAMPFIRE program in Zimbabwe established a benefit-sharing system that devolved management of rangeland to local community groups. The Man and Biosphere program (UNDP) established periphery areas surrounding core "protected areas" in which limited natural resource use was permitted. Every system has its own advantages and shortcoming but

mechanisms and institutions that govern the access to seed and germplasm, These mechanisms and institutions thus shape the distribution of genetic diversity information and establish the bases and norms for collective action for the deployment and "mise en valeur" of genetic resources.

The Matrix of Access, Conservation and Use: the human landscape

Unlike other natural resources such as forests, PGR do not derive their value solely from the physical artifact themselves - the proteins that make up the genes. Much of their value is determined when engaged in a relationship with the ecosystem, farmers, and scientists. Varieties are valuable because they contain characteristics *that are different from the characteristics of other varieties*. The value that plant genetic resources provide to breeders, farmers, humanity, and the ecosystem is an ability to adapt to changing environmental, market, and social conditions[4].

Agricultural biodiversity (including genetic diversity) is valuable to farmers for both commercial and non-commercial use. It sustains agricultural systems, ensures productivity, minimizes risks, attenuates shocks, provides insurance against volatile and imperfect markets, increases resistance and resiliency of ecosystems, and provides social and cultural values. Genetic diversity also has value to humanity; it provides species with the ability to adapt to changing stresses such as pests and diseases or climatic change. In addition, the use of diversity of plant genetic resources generate public benefits to today's generation and future generations by conserving genetic traits for future generations and supporting healthier ecosystems (Smale, 2002). The ability of the poor to access and use genetic resources has implications for farmers' productivity, livelihoods and farm ecosystem health, in both the short and long term timeframes.

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functions on the similar framework. Each use property rights to create a benefit-sharing incentive structure that leverages the social capital and enforcement mechanisms endogenous in local communities.

[4]Agricultural Biodiversity. Michel Pimbert. Background paper 1.Prepared for the FAO/Netherlands conference on the multifunctional character of agriculture and land.

The difference between the definitions of an ecosystem and a landscape reflect two distinct perspectives within the study of plant genetic resources. The visible diversity within an ecosystem is a function of the ecological relationships between plant, animal, biotic, and abiotic components. An agricultural ecosystem, for example, is characterized as highly regulated and mainly composed of domesticated plants and animals. Ecosystem analysis is essential for informing science about the natural changes that contribute to the disappearance of variety diversity.

At the landscape level we focus on how people who use the biological resources in the ecosystem are empowered and constrained by social rules that determine how an individual may interact with and modify an ecosystem. The landscape perspective recognizes the interplay between the users of the ecosystem, the social structure, and the environment; typically, multiple ecosystems can exist within a single landscape. The study of rights and collective action within a landscape changes the orientation from a focus people's relation to the natural world to a focus on social relations with respect to the natural world. The difference between landscape and ecosystem analysis is reflected in the change in terminology, from agricultural ecosystem to agrarian landscape. A single ecosystem (i.e. dryland forest) within a landscape can be managed under multiple and overlapping tenure regimes (i.e. common, private, usufruct, public) each with a different rules for access and use of genetic resources.

Effective common resource management should be coordinated at the landscape level (McCulloch, 1998). Uncultivated landscapes such as forests or pastoral lands are important to, and managed alongside, intensively cultivated agrosystems. The creation of appropriate property rights for different ecosystems and sustainable uses of genetic resources is still under investigation to produce policies and regimes that allow for multiple uses and users and foster the development of a new culture of responsibility. Where such property rights have been acknowledged and understood, biodiversity is more likely to be sustainable managed and even restored. This was the case in Nigeria as local communities began to replant and restore eroded forests (Clieve-cole, 1996). Plant resources gathered in uncultivated landscapes provide medicines for the majority of poor

rural communities and supply raw materials for non-agricultural income generating activities and trade. The concern with providing access to a diverse set of locally managed assets that underpin a sustainable livelihood has led to growing trend to decentralize management rights over plant genetic resources. This empowers the communities that were the customary managers of these biodiversity rich spaces that governments have sometimes failed to effectively manage (Godbole, ISE 2002).

Informal property rights that recognize the multiple uses of a landscape encourage the maintenance of biodiversity. The rights of individuals or groups to use resources, not only includes legal notions but also concepts of social norms (Eggertsson, 1991, 33). "[T]he strength and effectiveness of indigenous property rights institutions that still exist… often superced[e] national land laws in the eyes of local people," (McCulloch, 1998, 9). Traditional property rights - also known as informal property rights if they are not recognized or enforced by state authority - define the relationship between the society and the landscape, and establish property contracts within a historical and cultural context.

The maintenance of crop genetic diversity depends on the continued use, trade and movement of crop varieties among different groups and communities. This occurs in practice through the seed flow depends on farmers' access to seed and planting material- in other words, their access to PGR. The exchange of locally adapted varieties, the introduction to new varieties, and the movement of seed through its exchange, sale, and saving local seed from past harvests contributes to a robust seed system that is more likely to maintain optimal amounts of diversity.

Informal methods of seed exchange may include the sharing among neighbors and relatives or the transportation by migrant workers who bring varieties from areas where they work back to their home region. Formal institutions involved in the seed system can include seed certification programmes, commercial seed markets, community seed banks, or government programs that provide farmers with seed of improved modern varieties. Plant breeders and national seed centers often provide improved or virus-free and

genetically uniform seed to these markets and replenish seed after disasters. Both the formal and the informal networks work in complementary ways that increase famers'access to diversity and the availability of genetic variation.

In agrarian landscapes the use of biodiversity is often tied to the social and cultural traditions of communities that directly affect criteria for selecting and conserving local seed varieties. Specific types of crops carry with them associated knowledge and rules about who can produce them, how labor is allocated, and who profits from their sale. These customs about selecting and managing seed can be considered as PGR institutions since they represent "complexes of norms and behaviors that persist over time by serving collectively valued purposes". They are the building blocks of preference and taste, and indivisible from the allocation of value to varieties and characteristics (Uphoff, 1995). Changes in these customs and institutions ca engender a change in crop genetic resources, for example in Uzbekistan, elders remarked that the many varieties of the pomegranate species have become sweeter since their childhood because the market values that particular characteristic.

Informal property rights institutions indirectly influence the use of genetic diversity by decreasing the costs of accessing new diversity from forest reserves or uncultivated areas. In marginal environments, where introduced materials do not contain the required traits to survive the highly stressful environment, farmers domesticate wild varieties from reserves, protected areas, or uncultivated lands. Informal institutions which give farmers access to these resources may directly conflict with formal rules prohibiting entrance to the area, even though access is essential to the improvement of agriculture in the area. In Central Asia where water is scare and soil salinity is high, modern varieties of fruit trees only survive when grafted onto rootstock of local varieties that is often taken from local forest reserves or uncultivated areas owned by the state farms.

Traditional norms determining which social groups make decisions about particular species enables cultures to maintain local knowledge associated with particular crops. By affiliating knowledge of certain crop with subsets of the community that freely associate

with each other, traditional and new knowledge is continuously recycled and maintained. In rural communities information-sharing groups are normally segregated along gender lines, and knowledge about species associated with traditional gender-specific activities is accumulated accordingly. In Vietnam, men, as household heads, exercise decision-making authority over economically valuable crops such as upland vegetables, citrus species, mango, and coffee. Women make more decisions over tubers and roots, medicinal plants and lower value crops (Hodel, 22). Traditional property rights defining gender-crop roles are important to the institutionalization of knowledge within traditional communities which contributes to the maintenance of diversity and the provision of socially acceptable opportunities to both men and women.

Historically, traditional property rights have been assigned to group entities such as communities, user groups, and religious organizations that provide representation of the interests the community at large, including its poor. A consequence can be the maintenance of diversity, as is the case in Ethiopia where sacred groves managed by the Christian Coptic churches provide the landless access to non-timber forest products which enable the poor to survive. These forest groves contain some of the highest amounts of biodiversity in the country (ISE, 2002).

Traditional property rights giving open access to communal areas serve to maintain diversity by providing access to useful wild or semi-domesticated plants. In Kenya, *Amaranthus graecizans* L. a traditional edible leaf, is collected from the wild on disturbed grounds and sandy areas in communal areas along roadsides and rivers (Chweya, 72). Traditional property rights entitle to the landless poor access to this asset and in the process conserve this neglected and underutilized crops as a genetic resource. When access to communal areas is restricted, not only are livelihoods impacted, but species are no longer valued as the traditions associated with them disappear. For example in 1975, when a ***togai*** forest ecosystem in Uzbekistan was declared a protected nature reserve and the surrounding communities lost rights to access those genetic resources and the local knowledge for improving properties of fruit trees by crossing or grafting with wild relatives found in the forest was also lost. The surrounding communities still claim traditional rights to use the reserve land in the same way as

before - in contradiction to the formal laws - but they now value it mainly as transitory pastures because they are unable to develop or retain traditional practices that were a more conspicuous but more sustainable use of the ecosystem. The complex and multiple access regimes developed by local communities are embedded in cultural systems that allocate varying degrees of access and usufruct rights to biological resources. These traditional resource rights are often difficult to accommodate under formal property rights regimes. More empirical research ion how these rights are defined and transacted along with research on legal pluralism (see CAPRi working paper) could support local decentralized management of plant genetic resources, a key aspect of *in situ* conservation of agrobiodiversity.

Property Rights and the public and private values of genetic resources

Formal property rights have the greatest effect on those genetic resources that are used in plant breeding to produce a new cultivar. These genetic resources can be wild relatives of domesticated crops contain particular traits (such as drought resistance) that are valuable even though their product, (ie. the fruit), may not be. Genetic variation at the greatest risk of disappearance are those unique alleles[5] that are found in only a small fraction of all varieties, of which only small numbers are planted within a landscape. Unless the individual farmer is a plant breeder, the usefulness of the wild relative variety is small and it is not efficient for him to provide the inputs and space necessary to grow it. Communities recognize the public value of having many varieties and traditional property rights systems have developed to protect those wild-relative genetic resources growing in communal areas, in unused spaces alongside roads, et cetera. Traditional rights are best adapted to the local incentive structures but their influence can be undermined by formal property rights, particularly when formal rights privatize the accrual of benefits in an attempt to create an incentive for conservation and management.

[5] An allele is a variation of a particular gene. For example, the gene which determines eye color has different alleles each of which gives rise to a different eye color.

Anecdotal evidence from the literature suggests two separate factors, both influenced by formal and informal property rights regimes, are important to the management of biodiverse landscapes: land use patterns and the system of tree and plant management (Place and Otsuka, 2000, 27). Land use patterns, such as the conversion of forest ecosystems to agricultural ecosystems depend on expected profits. In cases where rights to exclude were not strengthened by use - where indigenous institutions provided all community member "virtually open access" to customary woodlands – woodlands were protected from changes in land use.[6] Once converted to agricultural land, strong property rights had the opposite effect. Strong tenure rights created incentives to invest in the land and led to greater tree investment and greater expected profits from the agricultural land (Place and Otuka, 2000). Involving property rights regimes is essential to the strengthening of collective action institutions and the development of policies to reverse genetic erosion.

Changes in formal property rights can also change the perception of how long an individual can use a particular piece of land. In Central Asia, where increases in the length of formal land tenure over the past ten years have encouraged the perception that land tenure can be very long-term, preliminary evidence suggests that farmers are using more biodiversity. In Uzbekistan farmers with limited 0 year land leases nonetheless overwhelmingly believe that a longer-term tenure is securable through the social custom of bribes. They plant twice as many different crop species as farmers who rent land for only one to three years.[7] Peasant farmers receiving lifetime tenure on their household garden cultivate an even greater variety of crop species (Thurman, 2001). They also make greater investments in the health of the land. In the same study, per capital expenditures on the farm per hectare were 1.5 times higher on long-term rented lands than on lands with leases of only one to three years (Thurman, 2001). Evidence from three provinces in China indicates that greater land tenure security and land transferability "had a positive impact on agricultural investment and… led neither to an increase in inequality of land

[6] In Uganda

[7] Other factors influencing the number of species grown on the fields include freedom to choose crops, access to fertilizers and pesticides and ecological variables. The correlation between land tenure security and the number of species grown has not been statistically verified.

distribution nor a reduction in household ability to cope with exogenous shocks" (Deininger and Jin, 2002). When appropriately and sensitively applied changes in formal property rights improve biodiversity without sacrificing livelihoods.

The greater use of crop diversity on long-lease farms suggests that biodiversity is used to enhance the health of the land. The more intensive use of diversity on household plots implies that biodiversity is utilized for its own value in providing variety for household consumption. The possibility to improve the conservation of plant genetic resources through the development of formal property rights is promising yet demands further study outlining what are those components defining a landscape which need be considered when coordinating formal property rights with traditional resource rights.

Incentives for PGR Use and Collective Action

Diversity in social and institutional environment amplifies the complexity of the landscape and often increases biological diversity. Communities with a patchwork landscape comprised of multiple sociological and ecological niches use, and hence conserve, the greatest amounts of diversity because the demands of ecological niches favor the use of unique varieties and plant types. Studies in Cuban, Ghanaian, Vietnamese, Nepalese and Guatemalan homegardens show that niches contain 60 to 250 species (Watson and Eyzaguirre, 2002). There is justification for further research on how social complexity and property rights shape the distribution and values of agro-biodiversity. Gender, culture and socio-economic status including land tenure are the main factors that would influence this relationship.

Social diversity in the types of people who have access to and can make decisions about genetic resources has been shown to be a close correlate of genetic diversity in crops and ecosystem because farmers grow the same crop for multiple uses and farmers value different characteristics in the same crop, depending on its use. For example, Andean women value large potatoes for food but also small potatoes processed for drying (Tapia, 1998, 28**)**. Other valued characteristics can include suitability for market sale,

consumption as a staple food, food security and drought tolerance, and production yield (Smale, 2001). Distinct groups also value different parts of the same plant. In Pocoata, Bolivia men are more interested in the grain production and women value the stover and craft materials (Iriarte et.al, 2000, 131). The combination of uses, characteristics, livelihood activities, and varieties creates demand for diversity at the species variety level. Ensuring the continued use of PGR requires that that demand translate into patterns of crop selection and planting.

Property rights, policies, and institutions determining collective action have large and indirect effects on variety demand in seed-exchange networks. Under ideal circumstances property rights can improve the facilitation of seed exchange among existing organizations and may spur the creation of new systems of information and germplasm exchange. Official and traditional institutions of seed exchange develop in response to the costs of locating useful varieties in the seed systems and *in- situ* experimentation with the new varieties. These costs are not minimal, and the sustained use and development of varieties require that users' perceived benefits will be recuperated over time.

In agroecosystems diversity is maintained when used as a tool to improve land productivity and sustainability. The traditional *milpa* system used in Mexico is a strategy of multi-cropping of legumes and maize that keeps the soil productive by returning to the soil the nitrogen absorbed by the maize. The *milpa* is an example of a technology that is only cost effective when land tenure is longer term because it is a more labor-intensive process. By creating ownership rights and by securing tenure regimes, property rights make long term investments in sustainability worthwhile and diversity an effective technology.

Econometric analysis of forest and farm systems shows that collective action increases both public and private returns on investment (Baland and Plateau, 1996; di Falco, 2002). For physical common resources users create institutional arrangements and management regimes to allocate benefits equitably and over time achieve better conservation of

resources (Agrawal, 2001). Likewise, voluntary collective farms have been shown to use more plant biodiversity to maintain land productivity than private farms (di Falco, 2002).

Shifts toward market-oriented production may disenfranchise one or more groups from a socially acceptable livelihood strategy. Property rights linking markets to farmers inform the incentive structure and immensely influence the use of crop diversity for farmers' livelihoods. Variety loss of rice in South Asia is partially a consequence of orientation to foreign markets when local market demand did not provide the same level of economic compensation during the green revolution (Rhoades, 1991, Hargrove et al., 1988 in King, 2000). Global market demand does not distinguish between varieties, so for farmers in developing countries to capitalize on the market they must grow the highest yielding varieties, regardless of the long term effects of fertilizer and pesticide use on the land, or the greater possibility that disease might destroy the crop (King, 2000).

Property Rights and their impact on equity and efficiency in genetic resources access and use

While society has paid significant attention to the private actions and ownership (mainly by firms) that underpin genetic resource innovation using biotechnology, very little attention has been paid to property rights and collective action of agrarian communities and cultures for whom genetic resources are essential livelihood assets. The granting of exclusive intellectual property rights over germplasm might reduce access to plant genetic material to everyone, including poorer farmers. Thus, even the seemingly positive benefits of granting intellectual property rights to local communities may lead to unintended negative consequences. Farming communities use genetic resources to meet a variety of livelihood, environmental and cultural needs, and innovations in genetic resources over time are often the product of long-term collective efforts of communities. No single individual can claim to be owners or originators of the innovation process and the resulting genetic resources. The above highlights problems related to assigning property rights to genetic resources to individuals or groups of users, as well as the fact

that failed recognition of local indigenous rights might facilitate external actors appropriating exclusive rights over genetic resources they did not, in fact, "innovate".

Along with the equity issues, however, remain serious debates regarding the costs of establishing intellectual property rights to genetic resources even if local indigenous groups could legally establish claims to local resources. No matter who receives the property right, privatization itself may well lead to reduced availability of germplasm. Indeed, the mere existence of such rights may still not offer sufficient incentives to develop markets that adequately capture the value of biodiversity, again, because of the public goods nature of many of the benefits. In particular, assigning exclusive property rights to germplasm might reduce the ability of poorer farmers to access seed germplasm, given that often less informed, less educated and marginalized rural populations are at a disadvantage in claiming ownership.

The issue of rights to germplasm highlights the existence of multiple legal and regulatory frameworks, from international agreements to national laws, from customary legal frameworks and *sui generis* systems to less formal arrangements such as those embodied in local farmers' seed systems; all of which influence the debate on the possible benefits, and distribution of those benefits, of IPR. Analyses of the costs and benefits of assigning intellectual property rights need to take into account the prevailing structure of rights and norms regarding use and management of local genetic resources. For instance, where different systems coexist and overlap, local rules of seed flows may well contradict with commercial agreements. Which institution prevails at any point in time depends on the existing power and social relationships between different claimants, and the result clearly affects equity and poverty outcomes. An analytic framework based on the concept of legal pluralism, and informed by such research on rights to land and water resources,[8] is required to understand how these different institutions interact and reach different outcomes.

Conclusion

A description of formal and informal property rights is an essential baseline analysis of how plant genetic resources are deployed and maintained within agrarian landscapes. Property rights and collective actions are also starting points for analyzing how these resources can be maintained and their value enhanced for improving the livelihoods of the rural poor. Gender, culture and socio-economic status are key parameters for understanding how different rules and institutions can be mobilized to ensure more equitable access and sustainable use of genetic resources. The fundamental research issues lie in the ways rights and institutions for collective action can overlap or be complementary. For example we need more analyses of where, how, and what happens when the two spheres of rights overlap. Public, common, private, usufruct, and other user rights for different groups emerge from the overlap of these two general categories of property rights.

Studies that form part of the 'New Institutional Economics' (North, 1990; Eggertson, 1988; Baland and Plateau, 1996) and institutional scientists' studies of indigenous collective action institutions (Ostrom, 1990; Wade, 1987; Agrawal, 2001) have provided theoretical guidelines explaining the principles on which collective action institutions for forest, water, and pasture resources operate and on which people participate in them. Plant genetic resources are intrinsically different from other common property resources because the value of PGR is not in any single variety, but in the bundle of varieties, *each of which contains different characteristics from other varieties*. For the unique category of common resources that are genetic resources, the underlying axioms explaining collective action strategies, communal management, and incentive structures for the conservation and maintenance are still unidentified and offer a new focus of study for the discipline of institutional theory.

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[8] Meinzen-Dick, Ruth S. and Rajendra Pradhan. 2002. Legal Pluralism and Dynamic Property Rights. CAPRi Working Paper No. 22. Washington, DC: CGIAR System-Wide Program on Collective Action and Property Rights. http://www.capri.cgiar.org/pdf/capriwp22.pdf

As we develop tools to describe and map the relationships between human institutions and diversity we can begin to answer some of the central questions on the debate about how to reverse the loss of diversity.

- How has diversity changed in response to devolution and changes in landscape management?
- Does the diversity of ecosystems change as expected under different property rights regimes?
- How is the speed at which diversity increases or decreases related to property rights, access regimes, and culture?
- How do landscape ecologies and diversities change in response to changes in property rights?

Plant genetic resources are still largely in the hands of the rural poor, as biological assets for their livelihoods. They are the raw materials that allow farmers to resist shocks and climatic variation. Although farmers' assets can be enhanced by greater access to commercial germplasm, loss of access and rights to local germplasm takes power away from farmers and limits their contribution to future diversity and evolution in the plants and animals that sustain humanity. Farmers' rights to freedom from dependence[9] include the right of access to the germplasm adapted over generations to meet the requirements of specific ecosystems. Property rights affect farmers' access to plant genetic resources by influencing the incentive structures that have maintained the traditional varieties over generations and by defining the extent of collective action is possible within a community. Understanding property rights and collective action for genetic resources can help scientists, development specialists, and policy makers take account of local and formal institutions that give farmers, fisherfolk, pastoralists, and forest dwellers the capabilities to manage their environments and reduce poverty.

[9] This is an expansion of Sen's arguments that each individual has inalienable basic rights to freedoms that enable them to reach they full capacities (1999).

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