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PROPERTY RIGHTS, COLLECTIVE ACTION, AND TECHNOLOGIES FOR NATURAL RESOURCE MANAGEMENT

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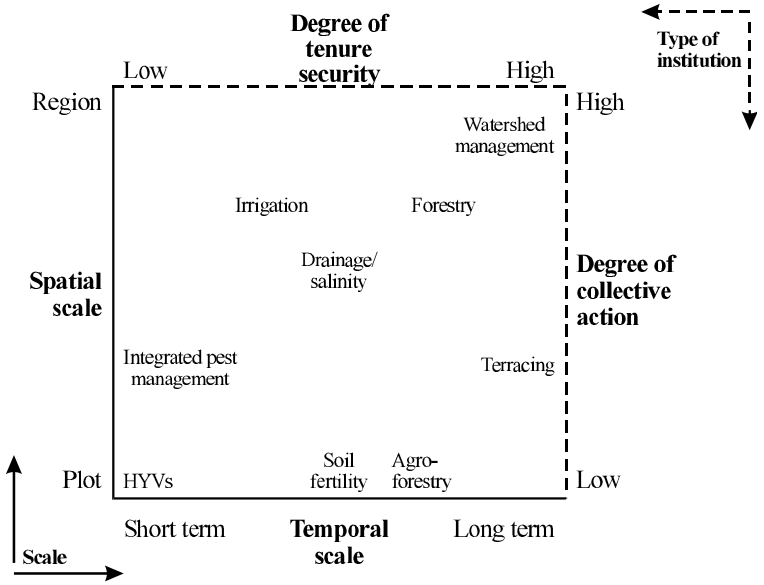
Degradation of natural resources has become a global problem that threatens the livelihood of millions of poor people. Many promising technologies for natural resource management are available to address these problems, but farmers and others often fail to adopt them. Why is this? Although many factors can be identified, lack of secure property rights and collective action deserve greater attention from policymakers and technology developers.

HOW PROPERTY RIGHTS AND COLLECTIVE ACTION AFFECT TECHNOLOGY ADOPTION

Conventional agricultural technologies like high-yielding varieties (HYVs) and fertilizer can be adopted on a single plot or farm and give returns within a season or year. By contrast, many natural resource management technologies take years to give full returns. If farmers do not have secure rights to natural resources, they have no incentive to adopt these technologies because they are not assured of receiving the benefits. Some technologies also need to be adopted over a wide area to be effective, so farmers who wish to adopt them must cooperate with their neighbors. Moving from agricultural to natural resource management technologies expands both the time horizon and spatial scale of technologies. Figure 1 illustrates the time and spatial scale of various technologies. Integrated pest management offers rapid returns but requires collective action over a wide area. By contrast, terracing may be very localized yet investment is continuous and long-term. Watershed management, irrigation systems, and salinity control require both long time horizons and coordination among farmers. Finally, river basin management involves such a vast spatial scale that it even extends beyond the realm of strictly local collective action. Here state intervention or co-management arrangements involving the state and local institutions may offer the best solution.

Several of the technologies specified in Figure 1 could be broken down into subgroups to more accurately reflect their spatial and temporal characteristics. Within agroforestry, community nurseries require high degrees of collective action to sustain them, whereas, given the short time needed to derive benefits from the technology, long-term property rights are less important. By contrast, agroforestry aimed at producing fuelwood or poles requires an extended duration for production, yet the practice is more individualized and requires little, if any, coordination beyond the household level. This framework helps determine whether the status of property rights or collective action is likely to constrain or enable various technology

Figure 1—Property rights, collective action, and sustainable agricultural and natural resource management



Note: Location of specific technologies is approximate, for illustrative purposes.

choices. It can also provide guidance on developing and disseminating technologies that are appropriate for an area's institutional context. Technologies operating on a landscape scale may be more appropriate where traditions of cooperation are strong, while those that require an extended duration to produce benefits may realize greater success where tenures are long term and reasonably secure.

Property rights and collective action are also important in determining who benefits from productivity increases, both directly by determining who can reap the benefits of improvements in factor productivity and indirectly through their effects on land markets, access to credit, and the like.

Property Rights

Property rights include not only ownership of resources as defined by state laws, but also a variety of rights from customary law and local practice. For tenure security, the rights should provide

- excludability, to allow those with rights to exclude others from using a particular resource;
- duration, to provide a sufficient time horizon to reap the benefits of investments;
- assurance, from institutions that can enforce an individual's rights; and
- robustness, the number and strength of the bundle of rights an individual possesses.

Policy prescriptions for Africa and other developing countries have often argued for the need to replace community-based land tenure institutions with freehold tenure backed by formal titles. Yet much empirical evidence shows that establishing titles and privatizing land ownership is unlikely to increase adoption of technologies because it does not enhance tenure security, and may even weaken it. Indigenous property rights institutions have often proved effective in recognizing and enforcing secure property rights for community members, and where these institutions persist, a title does little to strengthen the land rights of community members. Where indigenous local systems have broken down (because of either internal factors or external threats to the security of tenure, such as outsiders attempting to claim land), registration or land titling may be needed. This may also be true where commercialization has advanced to the point where efficient credit and land markets are needed.

Collective Action

Collective action for natural resource management can include joint investment in buying, constructing, or maintaining local infrastructure and technologies; setting and implementing rules to exploit a resource; representing the group to outsiders; and sharing information. As important as collective action is, it cannot be assumed to exist. Research shows that greater social cohesion is likely if the number of users is fairly small, if they are alike in terms of shared values and dependence on the resource, and if the net benefits from group membership are substantial and equitably distributed. However, collective action does not guarantee equity. Women, for instance, may have little voice in the decisionmaking process while still being accountable for labor contributions.

Where there are sufficient incentives but governance mechanisms are lacking, local leadership or external community organizers can facilitate collective action. But to be sustainable, governance needs to be institutionalized, not dependent on actions of a single person. Linkages between collective action and property rights are especially strong in the management of common property resources. Tenure security for the users of common property resources requires that

- an effective local institution manages and regulates the use of the resource, to assure members that if they abide by the rules, others will also;
- the group or community has secure ownership rights over the collectively managed resource; and
- individuals have secure membership in the group (to have continued use rights to the resource).

Many common properties are under pressure today from population expansion, increased competition for resources, and breakdowns in management institutions arising from market forces, policy interventions, and challenges to the rights of the community by outsiders. Policies to recognize community rights and local organizations can help natural resource management in such situations.

FACTORS INFLUENCING TECHNOLOGY CHOICES

Many other factors besides property rights and collective action keep farmers from adopting technologies for natural resource management. However, even many of those factors interact with property rights or collective action.

Infrastructure and Information

Farmers cannot adopt technologies if they do not have information about the technology or the returns from adoption, or if roads and transport are too poor for them to acquire technological inputs and market their output. The distribution of technologies and information is linked to property rights. At the community level, extension services often favor land owners, which gives greater access to men and the wealthy. Collective action can strengthen the bargaining power of disadvantaged

community interest groups, and formation of networks among community members can facilitate access to information. Networks and other forms of collective action may also enable coordination of technology adoption efforts. For example, establishing a communally managed seed bank may facilitate individual tree planting and provide a forum for information sharing on the technology.

Environmental and Price Risk

Risk-averse and low-wealth farmers are often reluctant to adopt technologies because they need stable income and consumption streams. The ability to manage risk can be affected by prevailing property rights and collective action institutions. For example, locating plots of a single farm in different microclimates reduces the possibility that a farmer's full range of crops will be lost to pest or weather problems. Common property resources frequently function as a buffer against risk. Pastoral and agropastoral populations occupying arid and semi-arid regions rely on herd mobility on communal rangelands to mitigate their risk exposure. Collective action enables risk sharing and diversification and inspires mechanisms for collective self-help, such as reciprocity norms.

Wealth

Wealth is intricately linked to power and property rights over natural resources, affecting people's options for adopting technology. In Pakistan, for example, farmers who own more land are wealthier and more likely to install tubewells; their control over groundwater in turn further increases their wealth.

The bundle of one's property rights and the security of those rights combined with one's level of assets, income, and food security affect the degree to which one discounts possible future gains. Those who possess a higher quantity and quality of endowments will place a higher future value on medium- and long-run benefits produced by investment in technologies. They are less constrained by food insecurity and risks than low-wealth actors.

By serving as a risk-sharing device, collective action can alleviate food insecurities and other survival risks to lower the degree of future discounting and therefore constraints on technology adoption. In addition, collective action helps realign the distribution of gains from a resource by facilitating adoption of more advanced technologies that require "lumpy" investments. In Bangladesh and Pakistan, groups of small-scale farmers, including landless people and women, obtain rights to groundwater by collectively purchasing and managing wells and pumps.

Credit

Credit can be a way of overcoming wealth constraints to investment. It is often argued that farmers need individual title to land to offer as collateral for credit and that privatization will give small farmers access to formal financial services. However, formal financial institutions remain rare in many rural settings, particularly for agricultural lending, which is typically considered risky. In fact, it is questionable how important a constraint formal collateral is relative to the large transaction costs involved in rural lending. Other forms of collateral may prove more appropriate, or even more effective, for reducing the risks of lending to low-wealth borrowers. The many examples of informal financial institutions undertaking successful group lending schemes may be seen as substituting collective action for conventional property rights as a form of collateral. Credit groups may even enhance opportunities for collective action in natural resource management. If groups are already formed around a common purpose and share a common set of norms and values, this reduces the information and coordination costs of their organizing around another purpose.

Labor

Labor bottlenecks resulting from high labor requirements are also cited as a constraint to technology adoption, especially if new technologies create seasonal peaks that overlap with other agricultural activities. Collective action and reciprocity arrangements may be employed as a means to overcome household labor shortages, particularly in cash-scarce economies, thereby facilitating the use of more labor-intensive technologies.

Within households, property rights often fail to correspond closely to labor responsibilities. In some cultures women may need to contribute labor to their husbands' plots in order to access plots for their own production. The introduction of a new technology, such as irrigation, can shift these labor demands and responsibilities. In western Ghana, the spread of cocoa as a commercial crop has led to men's demanding a greater share of women's labor to farm cocoa crops owned by men. In some cases, men have given women a stronger claim over land as compensation, a shift that is expected to result in greater technology adoption by women.

Other Conditioning Factors

Besides property rights institutions, other laws and community rules, norms, and ideas can act to expand or constrain people's technology choices. In a case from Mexico, farmers' adoption of conservation tillage practices is partially attributed to state agricultural policies,

including a law prohibiting the burning of crop residues. In South Asia, taboos forbid women to use plows, restricting agricultural productivity and reinforcing women's dependence on men. Nevertheless, property rights institutions frequently shape and reinforce other rules, both legal and normative. For example, property rights vested in the state allow for laws that forbid the cutting of trees.

Although on the surface cultural norms that hinder technology adoption may appear to have equity, efficiency, or environmental drawbacks, they also tend to have more profound implications. In many rural African societies, communities promote cohesion and lessen exposure to risk through kinship and marital practices, which have implications for the distribution of property rights. In patrilineal societies, women often move to their husband's community after marriage and acquire secondary use rights to land without retaining rights to land in their birthright community. Likewise, the practice of having multiple wives means that male household heads must periodically redistribute land to accommodate newcomers as well as children. Altering the principles and property regimes that facilitate a cohesive community may increase exposure to environmental risk and diminish social security for women, at least in the short term.

Property rights and collective action are not fixed for all time but are dynamic institutions. The choice of natural resource management technologies will inevitably shape the institutions underlying property rights and collective action. Technologies that have large spatial spillover effects, such as irrigation, are likely to cause farmers to demand common property regimes and collective action given the gains to be realized from coordinated efforts. However, if incentives for adoption are not built into property rights and collective action institutions, if farmers lack key information, and if transaction costs of coordination and enforcement are not reduced, then technology adoption will not succeed and unsustainable outcomes may prevail. Hence, the ability of a society or community to efficiently adapt determines its potential for technical and institutional change.

Technologies with temporal implications, whereby the benefits of the technology are reaped at some future point in time, may call for enhanced tenure security. For example, planting trees may establish a claim on land. More generally, technologies that increase the value of a resource may induce privatization, enclosure, and the exclusion of some customary uses. Yet the gains to some households and individuals from such institutional change are frequently offset by losses to others. Empirical studies have revealed a negative correlation between household income and reliance on common property resources for subsistence purposes. Women especially depend on resources from common property to provide for their family's needs or for their own security where private property does not guarantee them access in the case of widowhood or divorce.

IMPLICATIONS FOR EFFICIENCY, EQUITY, AND ENVIRONMENTAL SUSTAINABILITY

Adoption of new technologies is not an end in itself. Rather, technological change should be evaluated in terms of its contribution to broader goals of growth, poverty alleviation, and environmental sustainability. Such outcomes are strongly influenced by the nature of property rights and degree of collective action. Tenure security may elicit higher productivity and more efficient outcomes by ensuring that only those who invest reap the benefits from doing so and that the right to do so is guaranteed for a long enough period in the eyes of the producer. Likewise, tenure security can provide incentives for producers to conserve resources by assuring them future benefits. However, the degree of tenure security within a community or among communities is not necessarily uniform. Wealth, power, and status influence one's tenure security and thus shape equity and environmental outcomes. Collective action is a critical component of tenure security in common property regimes and a means of coordinating resource management across private holdings.

Property Rights and Technology Adoption

Technology development has laid much emphasis on increasing productivity. However, simplistic analyses of efficiency can lead to distortions. Many customary tenure regimes permit different users to exploit different "niches." For instance, pastoralists and cultivators may use the same land; irrigation, fishing, and domestic users draw on water resources; other producers exploit forests for timber, firewood, and minor forest products. Technologies that increase the production of one good at the expense of others do not necessarily improve efficiency. For example, introducing new tree species or forest management practices may maximize production of logs but sacrifice kindling and minor forest products critical to local resident livelihoods.

Privatization of common property and land under communal tenure tends to lead to loss of multiple user rights in favor of more concentrated resource holding by a less diverse set of interests. Research has linked conversion to freehold tenure to loss of access to land and other resources by smallholders and large-scale land acquisitions by wealthy producers, government of-

ficials, and speculators, with dubious gains for efficiency. Where purchasers are mainly interested in short-term profits with little stake in the long-term productivity of the land, soil fertility and other natural resources may be depleted.

Evaluation of technology efficiency also needs to consider risk and transaction costs. Targeting wealthy households often shows the most apparent productivity gains because farmers with large holdings have a greater capacity to adopt mechanized and other capital-intensive technologies that lend themselves to more efficient outcomes, particularly in labor-scarce environments. Low-wealth households face greater constraints and will likely place a higher value on stability of earnings. Therefore they may be more risk averse. Incorporating transaction costs and risk considerations in efficiency calculations shows the rationality of livelihood strategies employed by the poor and broadens appreciation for the scope of technologies deemed to be efficiency improving.

Introducing technologies that are unsuitable for small-scale farmers or those with less secure tenure exacerbates inequalities. Determining the temporal and spatial scale of technologies and relating this to the local distribution of tenure provides an indicator of where this is likely to be problematic. For example, the scale neutrality and short-term benefits of HYVs means that small farm size and tenancy are not constraining (though risk aversion and credit constraints have often limited adoption by small farmers). By contrast, tubewells or tractors are "lumpy" investments requiring a longer time horizon and a larger service area to be profitable and so are more likely to be purchased by larger farmers or groups of small farmers with long-term rights to resources. The fact that scale-neutral technologies often require investments in large-scale technologies (such as irrigation) to be effective can undermine adoption of seemingly equity-enhancing innovations. Although common property regimes do not assure equitable outcomes, they do accommodate multiple users beyond the household level and so are better equipped than private property to spread benefits more evenly. However, common property regimes and collective action often fail to embody impartial sharing rules and equal distribution of power. Even when users have equal rights to a resource, the ability to exploit it may depend on one's access to the private means of production.

Ownership of property enhances the status and bargaining power of individuals within both the household and the community. Greater control over resources tends to enhance men's capacity to influence community power structures and exert political leverage with government officials and others responsible for technology distribution, infrastructure, and market development. The same is true for the wealthy. Technologies and their supporting infrastructure will therefore mainly reflect the interests of men who control substantial resources unless collective action emerges that is capable of reshaping policies and political outcomes to override these biases.

Collective Action and Technology Adoption

Various technologies will be more efficiently employed with collective adoption after material and transaction costs are assessed, whereas others will be more amenable to individual adoption. Alternatively, groups can use collective action to influence technological choices based on their anticipated impact on efficiency, equity, and environmental sustainability.

Used as an advocacy or political tool, collective action can enable marginalized interest groups to challenge property rights institutions, political and cultural institutions, and technology adoption. Organization and advocacy by artisanal fishermen in Kerala, India, led to restoration of their coastal common property rights, state financial assistance, and eventually a season ban on trawling by commercial fishermen. Collective action can be used to prevent the use of certain technologies or to modify their features or mode of adoption. Some fishers' organizations in the Philippines prevent the use of beach seine nets, dynamite, and poisons for fishing. In both of these contexts, local groups constructed artificial reefs to lure more fish and increase their food supply. Harvesting technologies thus shifted away from extractive practices, a shift that not only benefited small-scale fishermen, but also enhanced the productivity and environmental sustainability of coastal resources. Integrated community participation in decisionmaking about the design, implementation, and adaptation of technologies not only ensures that new technology does not disproportionately and inefficiently increase the workload of marginalized groups, but also permits reduction of overall labor inputs.

Linkages and Trade-offs

Inequities may also carry environmental implications. Use of pesticide technology by large farmers may generate negative effects for small farmers if they do not have access to it, especially if the chemicals eliminate predators that would otherwise keep pests in check. Inadequate access to land and technology by the poor can lead to overexploitation and degradation of resources. But where indigenous property systems have broken down so that members no longer are assured of benefits

from investments or long-term management practices, individualization of resources can facilitate more sustainable resource management practices. Efficiency, equity, and environmental objectives may also involve trade-offs. Maximizing efficiency involves selection, whereby some inputs (labor, capital, land) lose relative to others, leading to inequitable outcomes. Even within input categories, substitutions are made. In the United States, efficiency-enhancing technologies along with certain macroeconomic factors have increased the demand for skilled labor at the expense of unskilled labor.

Efficiency and environmental goals are often at odds as well. Efficiency measures tend to assess only the private financial costs of inputs and neglect social and environmental costs. Privatization of such resources as rangelands and fisheries has been advocated as a measure to control stocking rates and improve resource management to enhance profitability. Yet failure to account for fragility and environmental variability has resulted in overgrazing, soil erosion, and other forms of degradation on many privatized ranches and sedentarization schemes.

However, the trade-offs may be overstated. In the case of natural resource management techniques such as agroforestry, environmental degradation can raise the perceived value of products, leading to investment in technologies that conserve the resource base. Also, when efficiency criteria are placed in a dynamic framework, the value of a resource over time is captured and conservation often emerges as the optimal strategy. When transaction costs and risk considerations are incorporated into efficiency calculations, livelihood strategies of the poor can be seen as economically rational. Likewise, when productivity measures include the value of nontraded goods and services that poor households (especially women) obtain for their livelihood and security, an equitable distribution of resources or technologies that favors the disadvantaged may be seen as highly productive. Appreciation of less tangible economic and social dynamics broadens the scope of technologies deemed to be efficiency improving, so that the poor are not left behind or hurt by technologies.

POLICY IMPLICATIONS AND AREAS FOR RESEARCH

Strengthening local institutions of property rights and collective action increases the probability that people will use many of the new technologies for resource management. However, no single property regime is most appropriate for a particular technology in every instance. Even if it were, simply passing laws specifying the rights and responsibilities of individuals, groups, or government agencies is not enough, unless effective institutions exist to monitor and enforce those rights. Local law derived from a number of sources may have an equal or greater influence on actual behavior. The evolution of property rights must be understood as a process of institutional change, in which resource users themselves play an active role.

Similarly, collective action cannot be dictated by outsiders. However, policies such as employing a cadre of institutional organizers have been effective in fostering local organizations for voluntary resource management activities. In Namibia, an organizing partnership of communities, nongovernmental organizations (NGOs), and the Ministry of Tourism and the Environment established participatory mapping systems and other institutions to jointly manage wildlife resources. These organizers, who may work for an NGO, university, or government agency, spend time in communities encouraging local participation in both direct activities and in decisionmaking about the structure of collective action. This approach has shown high returns in terms of adoption and sustainability of resource management practices.

Finally, property rights over natural resources can provide an important policy tool for strengthening collective action in their management. Just as individuals are unlikely to invest in technologies unless they have secure tenure, communities cannot be expected to adopt long-term practices if they lack long-term rights to the resource. Yet many governments have been unwilling to transfer rights to water, irrigation infrastructure, rangelands, or forests when they devolve management responsibility to user groups. The issues of community rights and ways of creating new common property resources (in place of government ownership) are emerging as critical issues in devolution programs.

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