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Exploring the Feasibility of Farmers' Rights

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In many developing countries, there is concern that a conventional system of plant breeders' rights provides no rewards to farmers for their role in the conservation and enhancement of agro-biodiversity. To redress this imbalance, developing countries are incorporating farmers' rights provisions in their plant variety protection legislation. This article examines the feasibility of farmers' rights provisions based on intellectual property rights. It argues that the farmers' rights provisions crafted by some developing countries will involve enormous operational difficulties, while IPR-based farmers' rights are unlikely to provide significant economic returns to farmers or farming communities. At the same time, farmers' rights provisions, as currently conceived, are likely significantly to dilute the incentives for innovation provided to institutional plant breeders.

The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs) requires all member countries of the World Trade Organization to enact a system of plant variety protection (a system of intellectual property rights for plant varieties)[1] within a specified timeframe. In many developing countries this has led to a divisive debate about the fundamental desirability of extending intellectual property rights (IPRs) to agriculture. The key economic arguments advanced for extending IPRs to plant varieties are that they will create incentives for private investment in plant breeding and facilitate the transfer of IPR-protected varieties from developed to developing countries.

But even while accepting the TRIPs obligation, several developing countries, especially those rich in biodiversity, have been concerned about the inequities in a system of plant breeders' rights. A key concern has been that, while plant variety protection (PVP) systems reward plant breeders for their innovations, they provide no rewards to farmers or farming communities that have conserved and enhanced agro-biodiversity over generations – the very biodiversity that constitutes the critical resource base for plant breeders. To address this imbalance, many developing countries are attempting to incorporate farmers' rights provisions in their PVP legislation with the

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1. Article 27(3)(b) of the TRIPs Agreement states 'Members shall provide for the protection of plant varieties either by patents or by an effective *sui-generis* system or by any combination thereof'. However, the Agreement does not attempt to define the ingredients of an 'effective' system. Plant variety protection (PVP) is akin to a patents system but with some important differences, two of which are that PVP generally allows for farmers' exemption and researchers' exemption, which are not allowed under patents. The former allows farmers to use the seeds of a protected variety saved from the harvest for replanting their land in subsequent seasons without payment of royalty to the breeder, and the latter allows researchers to use a protected variety as an 'initial source of variation' in the development of other new varieties.

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objective of rewarding farmers/farming communities for their role as conservers of biodiversity (GRAIN, 2002). These provisions also draw inspiration from the Convention on Biological Diversity (CBD) which recognises the 'sovereign rights' of nations over their biological resources and encourages them to ensure 'equitable benefit-sharing' in their exchange and use. The recent report of the Commission on Intellectual Property Rights (2002) set up by the UK Government calls for a system of farmers' rights as 'an important counterbalance to the rights accorded to breeders in the formal sector under PVP or patents'. The Commission suggests that implementation of farmers' rights at the national level, particularly by developing countries, should include: (a) protection of traditional knowledge relevant to plant genetic resources for food and agriculture; (b) the right to equitably participate in sharing benefits arising from the utilisation of plant genetic resources for food and agriculture; and (c) the right to participate in making decisions at the national level, on matters related to the conservation and sustainable use of these resources. There are expectations that the application of farmers' rights provisions can generate large revenues that can be used for community reward schemes or biodiversity conservation activities (Swaminathan, 1996).

This article attempts to assess the feasibility of implementing farmers' rights provisions. The Indian PVP legislation is used as an illustration, since it appears to have gone farthest in articulating farmers' rights provisions.

Rationale for farmers' rights

Till quite recently, plant genetic resources[2] (PGR), including farmers' traditional varieties, were regarded as a public good to be freely exchanged both within farming communities and between farming communities and institutional plant breeders. Even at the international level, PGR were regarded as the 'common heritage of mankind', not subject to the ownership of individual countries. The common heritage concept was enshrined in the FAO's International Undertaking on Plant Genetic Resources (FAO, 1983), which sought to create a framework for unhindered exchange of these resources between countries. The status of plant genetic resources as a public good was also to a large extent due to their characteristics, which led to complex valuation problems and the consequent failure of markets to develop. Some key features, which led to this failure, were as follows: (a) PGR have been conserved, enhanced and maintained over generations by a large number of farming communities and freely exchanged between them. It is inherently difficult to identify precisely the 'owners' of PGR. (b) PGR are a self-reproducing renewable resource; once transferred, the original owner has no control over the production and use of the resource. (c) Unlike other natural resources, the collection of PGR does not deplete the stock of the resource. Typically only a few grams of the resource are collected and this can generally be regenerated without difficulty. And (d) problems of valuing PGR arise from the uncertainty regarding their potential use and the difficulty in distinguishing between the value added to a new

2. Plant genetic resources can be defined as 'primitive cultivars, land races and wild and weedy relatives of crop plants' (Sedjo, 1988). These form the basic building blocks of new varieties and provide the pool of genetic diversity from which breeders extract desirable traits.

product (for example, a new plant variety) by PGR and the value added by the research and development input (OECD, 1996; Swanson, 1997; Kloppenburg, 1988).

While uncertainty about potential use and complexities of valuation may prevent the pricing of plant genetic resources through normal market mechanisms, this need not preclude farming communities and countries rich in these resources from charging a pure economic rent for their use. Developing suitable institutional mechanisms for appropriating economic rents may, no doubt, have been very difficult. But it appears that farming communities and countries rich in plant genetic resources did not feel the need to do so as long as they had access to the new varieties developed using their resources and the loss of genetic diversity was not recognised as a serious issue. The advantages of a system of free exchange of PGR were also underscored by the Green Revolution – which was based on new varieties developed through the extensive and free exchange of PGR between national and international public research institutions. The fact that these exchanges, and the adoption of new varieties, were unencumbered by intellectual property rights was probably an important factor in the success of the Green Revolution.

The perceptions of developing countries regarding free and unrestricted international exchange of PGR have undergone a significant change in the last two decades. The change has come about in the context of growing concerns about the rapid loss of biodiversity relevant for agriculture and the increasing application of IPRs by developed countries to plant varieties. The two key arguments for moving away from the common heritage principle are the conservation argument and the equity argument. At the sub-national level, these arguments provide the rationale for a system of farmers' rights.

The conservation argument

The major problem in treating PGR as a public good is that they provide no rewards to their owners and no incentives for their conservation. The narrowing down of the base of genetic diversity underlying agricultural production can be gauged from the fact that, although humans have utilised 100,000 edible plant species over their history, barely more than 150 are now under cultivation (Swanson et al., 1994). Of the thousands of species considered edible, there are now only 20 species, which produce a large proportion of the world's food (Vitousek, 1986). The factors behind the loss of diversity can be understood by considering the incentives and disincentives facing a country or an individual farmer or community regarding the use of PGR, especially the incentives that favour the conversions of wildlands to agriculture and in particular the conversion from traditional agriculture to more specialised modes of agricultural production. From the point of view of a farmer, community or even, in the short term, a country, such conversions may be economically advantageous. From a global perspective, however, the aggregate effect of such conversions is undesirable, when it leads to critical levels of loss of the world's biodiversity (Swanson, 1997).

There is often a divergence between the immediate interests of individuals or communities and those of the global community, which cannot afford the loss of PGR (FAO, 1995). Thus, farmers, communities and countries that develop and conserve agro-biodiversity generate externalities at the global level; they produce values for which they receive no returns and are without incentive to continue producing them.

With the existing regime of free exchange of PGR, communities rich in genetic resources in traditional agriculture will see no reason to invest in the retention of this biodiversity. Even values of PGR, which are appropriable, are appropriated at a higher level in the chain (for example, by seed companies or plant breeders through plant variety protection). In this system, the loss of biodiversity will tend to accelerate and threaten the resource base for future plant breeding innovations. The conservation rationale behind 'farmers' rights' lies in the fact that it can provide a framework within which farmers/farming communities can appropriate some of the global values of agro-biodiversity, thus creating a structural incentive for the retention of plant genetic resources. The concept of 'sovereign rights'[3] over biological resources enshrined in the Convention on Biological Diversity can be seen as an attempt to extend the conservation argument to the level of countries.

The equity argument

The view that free international exchange of PGR is inequitable for developing countries has arisen in a context where the finished products of research in plant breeding are increasingly subject to patenting and other forms of intellectual property rights (IPRs). This trend is exemplified by the expanding membership of the UPOV.[4] IPRs for new plant varieties are generally justified on the ground that they provide necessary and legitimate returns on investment in research – without which no further progress in plant breeding would be possible. But the availability of PGR today is the result of enormous efforts towards conservation, selection and improvement of germplasm over centuries by rural communities in different countries that go unrewarded when PGR are freely appropriated for research. Thus, there is a fundamental asymmetry between rewards accruing to PGR that form the basis of development of new varieties and rewards accruing to new varieties that are the products of research. Farmers' rights provisions represent an attempt to redress this asymmetry in the reward structure.

At the international level, given that developing countries are often the major contributors of PGR for research and developed countries are producers of new varieties protected by IPRs, this translates into an asymmetry in the reward structure for developed and developing countries for the respective contribution they make to the improvement of plants (Kloppenburg, 1988; Mooney, 1979; Shiva, 1991). This asymmetry persists even in a situation where countries are strikingly interdependent in PGR. It is therefore argued that developed countries, which are poor in genetic resources, have received a substantial largesse from the developing countries rich in

3. The recognition of 'sovereign rights' over PGR is not equivalent to the attribution, or existence, of property rights over individual resources. It only means that the state may – within the limits imposed by the nature of such resources – determine what type and modalities of property rights, if any, are recognised (Correa, 1994). The CBD attempts to create a framework in which countries that provide PGR can subject them to some form of property rights and seek economic or other rewards (e.g. technology transfer) when their resources are used for research elsewhere. These rights over PGR can help developing countries negotiate better terms of access to new varieties protected by IPRs.
4. UPOV is the International Convention for the Protection of New Varieties of Plants, whose member countries agree to provide Plant Breeders' Rights (intellectual property rights) according to certain agreed standards. The Convention of 1961 underwent revision in 1978 and 1991.

PGR. But this contribution of developing countries to agricultural production in developed countries has largely gone unrewarded. The concept of 'sovereign rights' over PGR can, therefore, be also seen as an attempt to redress this asymmetry in the rewards accruing to developed and developing countries.

Developing countries have attempted to give effect to 'sovereign rights' and operationalise 'equitable benefit-sharing' by enacting legislation governing access to biological resources. At the international level, the FAO's International Treaty on Plant Genetic Resources for Food and Agriculture (FAO, 2001) seeks to establish a 'multilateral system' for access and benefit-sharing. Governments agree to provide other governments (or other specified legal entities) with 'facilitated access' to a specified list of crops and forages. Falcon and Fowler (2002) point out that a common element in the approach to national access legislation is that all developing countries see themselves as sellers of genetic resources, while there appear to be no buyers. 'As a consequence, the legislation is laden with restrictions to access, designed more to prevent abuse than to maximise benefits' (p. 209).

Falcon and Fowler (2002) argue that the International Treaty (even when ratified)[5] will be hamstrung in promoting 'equitable benefit-sharing' by the limited coverage of crops, the non-participation of key countries[6] in the multilateral arrangements, and the difficulties in precisely identifying the centres of origin of specific plant genetic resources. More importantly, they argue, lack of norms for benefit-sharing, narrow definitions of situations where benefit-sharing will apply,[7] and lack of substantial markets for plant genetic resources, all imply that the multilateral provisions of the treaty are unlikely to generate substantial funding. At the same time, the new institutional arrangements at the national and international level are likely to seriously constrain international exchange and restrict access to PGR for crop improvement, especially for developing countries. Many of the factors that may affect the success of benefit-sharing provisions at the international level are extremely relevant in the evaluation of the feasibility of farmers' rights provisions. Particularly important are the precise identification of farmers/farming communities responsible for the development of PGR and the contribution of specific PGR to the development of new varieties, the availability of markets for farmers' varieties and the norms for benefit-sharing with IPR holders.

5. The treaty will come into effect only after 40 countries ratify it. This could take several years.
6. It is generally believed that the US and Japan are unlikely to ratify the treaty.
7. Falcon and Fowler (2002) point out that 'benefit-sharing provisions' will not apply if a new variety is made available 'without restriction to others for further research and breeding'. Varieties protected by PVP remain available to others for research and use in breeding programmes. It does not appear, therefore, that PVP would trigger benefit-sharing under the new treaty. The provision will probably be relevant only when a new variety is protected by patents. Moreover, royalties will be assessed as a percentage of the profits from seed sales of particular new varieties, which is not a particularly large base. Further, the contentious issue of what level of benefits should be provided by those who acquire genetic material under the provisions of the treaty has not been spelt out; it has been left for the Governing Body of the treaty to resolve in the future.

Approaches to farmers' rights

While the need for farming communities to appropriate some of the value of the agro-biodiversity they conserve is clear, the precise modalities of an appropriation mechanism are not. We examine below three important approaches to the articulation of farmers' rights prominent in the literature (Swaminathan, 1996; Shiva, 1991). These approaches can be used in combination and the Indian PVP legislation in fact incorporates all three approaches.

Protecting traditional varieties

One approach to operationalising farmers' rights is through the provision of some form of IPRs for 'traditional' varieties, which have been developed by identified farming communities. This is generally seen as a method of addressing the imbalance between farming communities and plant breeders by a 'straightforward' extension of IPRs to the past innovations of farmers. These rights are provided in the expectation that the beneficiary communities will be able to derive royalties from the use of these varieties (in the same way as a plant breeder derives royalties from a protected variety). More importantly, it is expected that the IPR holders of traditional varieties will be able to derive revenues when these varieties are used as parental material in the development of new varieties (see below).

The attempt to protect traditional varieties through IPRs like PVP raises both conceptual and practical issues. The conceptual issues arise from the fact that IPR systems are generally designed to encourage the production of new knowledge. The novelty criterion, an essential element of IPR legislation, is used to demarcate knowledge in the public domain from knowledge in the private domain (which is the subject of IPRs and monopoly rights). However, IPR laws recognise the trade-off involved between granting monopoly rights to innovators for encouraging innovation and the widest dissemination of those innovations. This trade-off is generally sought to be resolved by granting IPRs of finite duration and by adjusting the 'breadth' of IPRs.[8]

The protection of traditional varieties through IPRs becomes feasible only if the novelty criterion is dispensed with. Protection of traditional varieties also implies that knowledge that is already in the public domain is sought to be pushed back into the private domain. As traditional varieties have existed for a long time, encouragement of the production of new knowledge is not relevant here; but it could be argued that the objectives are to encourage conservation and reward past innovation. However, if IPRs are seen as incentives for the conservation of traditional varieties, then the rights may have to be maintained in perpetuity. In fact, several NGOs do argue that rights granted to farmers over traditional varieties should be of indefinite duration. We are then led to two separate classes of IPRs, one set of rights granted to breeders of new varieties of finite duration (to encourage innovation) and another set of rights for extant varieties of infinite duration (to promote conservation). The application of IPRs to traditional

8. The breadth of IPRs refers to the scope of claims related to a patent, which the IPR holder is allowed. It is also important because it affects the possibilities of follow-on innovations based on the original protected innovation.

Box 1: Protecting traditional varieties under the Indian PVP legislation

Protection of farmers' traditional varieties in the Indian PVP legislation is made possible by defining farmers' varieties, including them in the category of 'extant' varieties, allowing protection to extant varieties even if they are not novel and defining the categories of persons who can apply for PVP rights. The relevant sections in the Protection of Plant Varieties and Farmer's Rights Act 2000, rather clumsily drafted, are as follows:

Farmers' variety:

Section 2 (k): 'farmers' variety' means a variety which –

(i) has been traditionally cultivated and evolved by the farmers in their fields; or
(ii) is a wild relative or land race of a variety about which the farmers possess common knowledge.

Extant variety:

Section 2 (j): 'extant variety' means a variety available in India which is –

(i) notified under section 5 of the Seeds Act, 1966; or
(ii) a farmers' variety; or
(iii) a variety about which there is common knowledge; or
(iv) any other variety which is in the public domain.

Varieties eligible for protection:

Application for registration.

Section 14. Any person specified in section 16 may make an application to the Registrar for registration of any variety –

(a) of such genera and species as are specified under sub-section (2) of section 29; or
(b) which is an extant variety; or
(c) which is a farmers' variety.

Registrable varieties.

Section 15. (i) A new variety shall be registered under this Act if it conforms to the criteria of novelty, distinctiveness, uniformity and stability;

(ii) Notwithstanding anything contained in sub-section (i), an extant variety shall be registered under this Act within a specified period if it conforms to such criteria of distinctiveness, uniformity and stability as shall be specified under regulations made by the Authority

Persons eligible for rights

Persons who may make application.

Section 16. (i) An application for registration under section 14 shall be made by –

(a) any person claiming to be the breeder of the variety; and
(b) any successor of the breeder of the variety; or
(c) any person being the assignee of the breeder of the variety in respect of the right to make such application or
(d) any farmer or group of farmers or community of farmers claiming to be the breeder of the variety;
(e) any person authorised in the prescribed manner by a person specified under clauses (a) to (d) to make application on his behalf;
(f) any university or publicly funded agricultural institution claiming to be the breeder of the variety.

(ii) An application under sub-section (i) may be made by any of the persons referred to therein individually or jointly with any other person.

varieties, therefore, involves significant departures from conventional IPR concepts, especially those of novelty and finite duration.

However, it is the practical issues that are likely to prove most intractable. Conventional PVP systems protect 'new' varieties that are 'Distinct, Uniform and Stable'. The 'distinctness' criterion, which requires a new variety to be different from all known varieties in terms of certain important characteristics, is related to the novelty requirement (which has to be dispensed with if traditional varieties are to be protected). However, the 'uniformity' criterion (which requires a variety to be 'sufficiently homogeneous' (UPOV, 1994a) or 'sufficiently uniform subject to the variation that may be expected from particular features of its propagation'[9] (UPOV, 1994b) and the 'stability' criterion (which requires that the characteristics of a variety remain unchanged after repeated propagation)[10] are criteria related to the legal requirement of identifiability for granting IPRs. Traditional varieties or farmers' varieties, though economically valuable, may not meet the strict criteria of uniformity and stability. There is considerable controversy over whether these strict criteria are really necessary to meet the legal requirements of identification, or whether some 'looser' criteria of identifiability can be used to protect traditional varieties (IDRC, 2001). These 'looser' criteria that can be used within a legal framework have seldom been spelt out by their proponents, though it is often argued that traditional varieties can be easily identified by farmers familiar with their use. An important question to be addressed is how a traditional variety can be protected, if it is not homogeneous and loses over time the very characteristics that identify it.

The attempt to confer IPRs on traditional varieties involves fairly heroic assumptions about the feasibility of identifying specific communities (or even individuals, as some NGOs would prefer) to whom the development of individual varieties can be attributed. Traditional varieties may be in use over large, dispersed areas. Even if the geographic origin of a traditional variety can be identified (see, for instance, the work of Vavilov, 1951), the attempt to attribute ownership to a specific community is likely to be fraught with uncertainty and arbitrariness. Devolving ownership on a specific community in the present day may do little justice to the generations of farmers whose efforts would have contributed to the evolution of the traditional variety. There is then the question of administrative capacity in developing countries to carry out credible investigations into the origins and ownership of varieties. It must be remembered that many developing countries (including countries like India, with large agricultural research systems) do not as yet have the infrastructure to implement even conventional PVP systems – for example, DUS[11] testing facilities and reference collections for establishing novelty. Extending administrative and scientific

9. To be considered homogeneous, according to the existing UPOV guidelines, the variation shown by a variety, depending on the breeding system of that variety, must be 'as limited as necessary to permit accurate description and assessment of distinctness and to ensure stability'. No doubt, this definition implies a certain tolerance of variations, depending on the different reproductive systems of varieties – a cross-pollinated variety has to be judged differently from a vegetatively propagated one. Whereas the maximum acceptable number of off-types is defined exactly for vegetatively propagated varieties and self-pollinated varieties, the tolerance limits in cross-pollinating varieties are set up only through comparison with comparable varieties already known.
10. Or in the case of a particular cycle of propagation, at the end of each cycle.
11. Tests for 'Distinctness, Uniformity and Stability'.

capacity to deal with 'ownership' issues is likely to be both prohibitively expensive and time-consuming.

In order to be effective or useful, IPRs need to be assigned to clearly defined legal entities that can coherently exercise these rights. The farming communities referred to in the farmers' rights discourse are not legal entities, and their boundaries and rules of membership are not precisely defined. Nor can we assume that farming communities are harmonious rural entities with a cohesive organisational structure that can decide about the exercise of IPRs. If IPRs are assigned to large, diffuse groups with poorly defined boundaries, we are likely to be beset with the same free-rider problem that leads to the loss of agro-biodiversity in the first instance; while all members may want to benefit from IPRs, not all may be willing to undertake conservation activities, incurring an economic cost.

It is also doubtful whether IPR-holding farming communities can actually derive any rents from the use of their varieties, because IPRs over plant varieties are generally exercised by controlling seed production. A plant breeder who gets his new variety protected is able to derive royalties because he alone can license the multiplication of seeds of his variety. In the case of a traditional variety already in extensive use, the IPR-holders are unlikely to have any control over seed multiplication. The seeds of traditional varieties are probably multiplied by other farmers using the variety (rather than by a seed company or co-operative); and these farmers, quite understandably, would be extremely unwilling to pay royalties for varieties they have been using for a long time.

Economic returns from the protection of traditional varieties can also be sought through provisions that allow IPR-holding farming communities to share the benefits from new varieties bred by plant breeders who use traditional varieties as parental material. The key provision, which facilitates such benefit-sharing, is the essential derivation clause. The essential derivation clause was introduced in the UPOV 1991 Convention (UPOV, 1994b) to discourage 'cosmetic breeding'. In the absence of such a clause, a variety containing only minor modifications of a protected variety ('the original variety') could be independently protected as a new variety, depriving the original breeder of a substantial portion of returns from his innovation. The essential derivation clause is intended to protect the innovations of first-round innovators from being appropriated by second-round innovators through minor or (agronomically) unimportant modifications. Under this clause, a variety defined as an 'essentially derived variety' can be protected as a distinct new variety if it conforms to the DUS criteria, but its commercial exploitation requires the consent of the breeder of the original variety. This protects the interests of the breeder of the original variety. The Indian legislation attempts to adapt the essential derivation concept to protect the interests of farming communities that may be the owners of traditional varieties.[12] If farming communities are given IPRs over traditional varieties and new varieties bred by plant breeders can be shown to be 'essentially derived' from these varieties, then the commercialisation of the new varieties will require the consent of the IPR-holding

12. The operation of the essential derivation clause requires that the original variety should be a protected variety. However, benefit-sharing arrangements can be conceived of, even when the original variety (e.g. a traditional variety) is not protected. Such arrangements are considered in the next section.

farming communities – enabling them to seek a share in the benefits from the new variety.[13]

Box 2: Essentially derived varieties

'Essential Derivation' clauses have been introduced in the PVP legislation of countries that are signatories to the UPOV 1991 Convention. The principle of essential derivation in UPOV 1991 was stated as follows:

A variety shall be deemed to be essentially derived from another variety ('the initial variety') when

(i) it is predominantly derived from the initial variety, or from a variety that is itself predominantly derived from the initial variety, while retaining the expression of the essential characteristics that result from the genotype or combination of genotypes of the initial variety;
(ii) it is clearly distinguishable from the initial variety; and
(iii) except for differences, which result from the act of derivation, it conforms to the initial variety in the expression of the essential characteristics that result from the genotype or combination of genotypes of the initial variety. [Article 14 (5) (b)] (UPOV, 1994b)

The economic principle behind this clause is that when an innovation has spillover benefits for other innovations – for example, it could reduce their cost or provide a necessary foundation – then from a social perspective, the first innovator should share in the profits from subsequent innovations. Otherwise the earlier innovator will have insufficient incentives to invest (Scotchmer, 1991). The second innovator will be induced to share his profits with the first innovator only if the second-round innovation (a new variety) infringes the rights of the first innovator. The objective behind the essential derivation clause is to define a set of circumstances in which such an infringement will be deemed to have occurred. However, if the later innovator knows that he would infringe a prior PVP right, he may be dissuaded from investing by the threat of *ex-post* hold-up for high licensing fees. This hazard might stifle second-generation products or reduce incentives for follow-on development of new varieties.

Though the principle behind the essential derivation concept is readily understandable, the precise definition of what constitutes an essentially derived variety is a highly complex and contentious issue. The concept of essential derivation relies on the similarity of genetic composition between the original variety and the derived variety. Implementing the essential derivation clause, therefore, involves defining a set of circumstances under which a successor variety can be said to have 'taken over' the genetic composition of the original variety. But conventionally, PVP systems have relied on morphological distinctness to establish novelty. It is generally accepted that morphological distinctness can be a poor indicator of differences in genetic composition (Smale, 1998). A variety, which has been held to be distinct (and therefore novel) on the basis of morphological differences, and has been granted IPRs, may not be sufficiently distinct from other varieties in terms of genetic composition. Introducing criteria for

13. It is probably true that the essential derivation clause in the Indian legislation has been introduced chiefly to protect the interests of the public sector research system, which has developed a large number of varieties in the past. Varieties developed and released by the public sector prior to the PVP legislation are afforded retrospective protection under the legislation from the date of release. The intention is that the public sector should be able to seek benefit-sharing from new varieties developed by the private sector that can be shown to be essentially derived from its varieties.

distinctness based on genetic composition (for the purpose of essential derivation alone) in a system that has traditionally relied on morphological differences poses considerable technical challenges that may shake the very foundations of conventional PVP systems. Difficulties in implementing the essential derivation concept also arise because of the need to balance the interests of the breeder of the original variety with the need to preserve incentives for further development of new varieties based on the original variety. A very broad definition of essential derivation may simply stifle the development of follow-on varieties.

While plant breeders use traditional varieties as parental material, this material undergoes several rounds of modification in the breeding process before it is incorporated into 'modern' varieties. In the context of present-day PVP systems, it will be difficult to establish that the 'modern' varieties are essential derivatives of traditional varieties. Given the above difficulties, it is doubtful whether the novel application of the essential derivation concept to farmers' varieties can yield significant returns to IPR-holding farming communities.

Compulsory benefit-sharing

Recognition of farmers' rights and rewards to farming communities for the conservation of agro-biodiversity can be provided through benefit-sharing provisions prescribed by PVP legislation, even when no IPRs are extended to traditional varieties. Such provisions come into play at the stage when breeders seek protection of their new varieties and involve the following elements:

(i) Requiring breeders (IPR applicants) to disclose fully the pedigrees of new varieties and the source of parental material. Breeders may also be required to certify that parental material has been legally acquired or that it has been acquired with the prior informed consent of the relevant farming communities.
(ii) Allowing farmers, farming communities or their representative organisations to stake claims to benefit-sharing based on:
    (a) claims of ownership of the parental material used by the breeder and the contribution that it has made to the new variety sought to be protected, or
    (b) claims regarding the contribution made by the community to the evolution of the new variety (for example, contributions made in selection).
(iii) Determining appropriate benefit-sharing norms in individual cases based on a verification of the claims made by farmers/farming communities and the commercial potential of the new variety.

The Indian PVP legislation provides a good example of such benefit-sharing provisions (see Box 3). These provisions are obviously well-intentioned and unexceptionable in principle. But little thought appears to have been given to what their implementation involves. Firstly, the provisions appear to ignore the complexity of the modern plant breeding process. Putting them into practice requires norms to assess the precise contribution made by parental varieties to the development of a new variety. Modern varieties have incredibly complex pedigrees. Take, for instance, a successful

Box 3: Implementing farmers' rights: mandatory benefit-sharing in Indian PVP legislation

The two key sections of the Indian legislation, which facilitate benefit-sharing between breeders and farmers, are as follows. References to 'Authority' are to the Plant Variety Protection Authority.

Determination of benefit-sharing by Authority.

Section 26 (1) On receipt of a copy of the certificate of registration under sub-section (8) of section 23 or sub-section (2) of section 24, the Authority shall publish such contents of the certificate and invite claims of benefit-sharing to the variety registered under such certificate in the manner as may be prescribed.

(2) On invitation of the claims under sub-section (1), any person or group of persons or non-governmental organisation shall submit its claim of benefit-sharing to such variety in the prescribed form within such period, and accompanied with such fee, as may be prescribed.

(3) On receiving a claim under subsection (2), the Authority shall send a copy of such claims to the breeder of the variety registered under such certificate and the breeder may, on receipt of such copy, submit his opposition to such claim within such period and in such manner as may be prescribed.

(4) The Authority shall, after giving an opportunity of being heard to the parties, dispose of the claim received under sub-section (2).

(5) While disposing of the claim under sub-section (4), the Authority shall explicitly indicate in its order the amount of the benefit-sharing, if any, to which the claimant shall be entitled and shall take into consideration the following matters, namely: –

(a) The extent and nature of the use of genetic material of the claimant in the development of the variety relating to which the benefit-sharing has been claimed,

(b) The commercial utility and demand in the market of the variety relating to which the benefit-sharing has been claimed.

(6) The amount of benefit-sharing to a variety determined under this section shall be deposited by the breeder of such variety in the manner referred to under clause (a) of sub-section (1) of section 45 in the National Gene Fund.

(7) The amount of benefit-sharing determined under this section shall, on a reference made by the Authority in the prescribed manner, be recoverable as an arrear of land revenue by the District Magistrate within whose local limits of jurisdiction the breeder liable for such benefit-sharing resides.

Certain information to be given in application registration.

40 (1) A breeder or other person making application for registration of any variety under chapter III shall disclose in the application the information regarding the use of genetic material conserved by any tribal or rural families in the breeding or development of such variety.

(2) If the breeder or such other person fails to disclose any information under sub-section (1), the Registrar may after being satisfied that the breeder or such person has wilfully and knowingly concealed such information, reject the application for registration.

Rights of communities.

41 (1) Any person, group of persons (whether actively engaged in farming or not) or any governmental or non-governmental organisation may, on behalf of any village or local community in India, file in any centre notified, with the previous approval of the Central Government by the Authority in the Official Gazette any claim attributable to the contribution of the people of that village or local community as the case may be in the evolution of any variety for the purpose of staking a claim on behalf of such village or local community.

(2) Where any claim is made under sub-section (1), the centre notified under that sub-section may verify the claim made by such person or group of persons or such governmental or non-governmental organisation in such manner as it deems fit and, if it is satisfied that such village or local community has contributed significantly to the evolution of the variety which has been registered under this Act, it shall report its findings to the Authority.

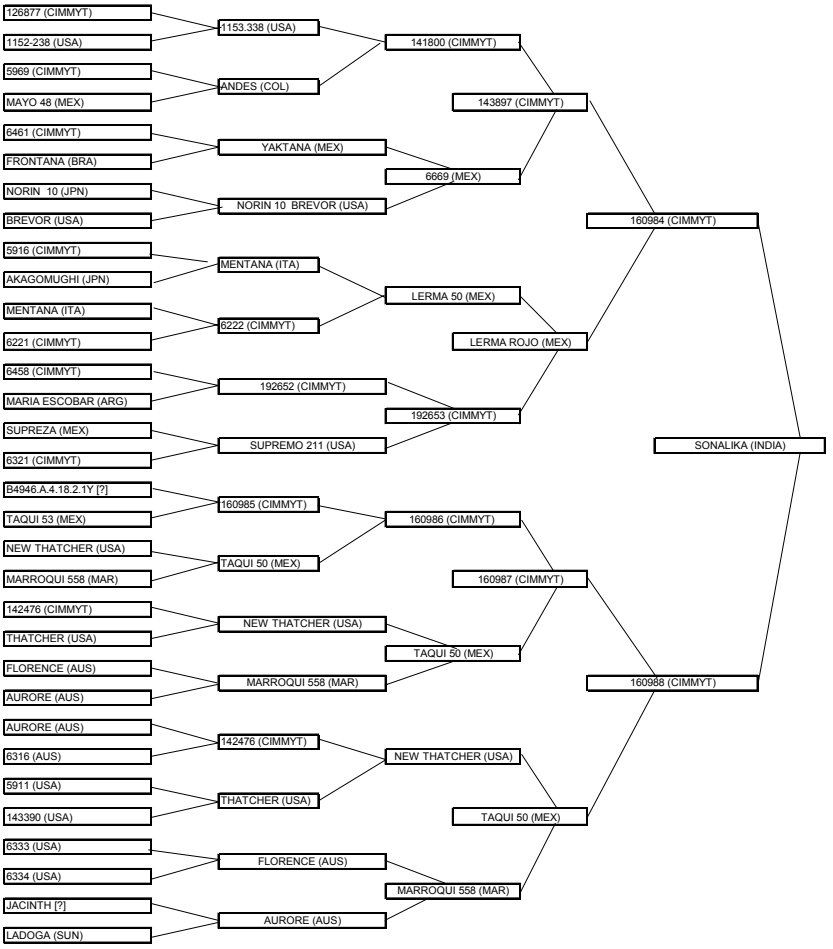
(3) When the Authority, on a report under sub-section (2) is satisfied, after such enquiry as it may deem fit, that the variety with which the report is related has been registered under the provision of this Act, it may issue notice in the prescribed manner to the breeder of that variety and after providing opportunity to such breeder to file objection in the prescribed manner and of being heard, it may, subject to any limit notified by the Central Government, by order, grant such sum of compensation to be paid to a person or group of persons or governmental or non-governmental organisation which has made claim under sub-section (1) to the Authority, as it may deem fit.

(4) Any compensation granted under sub-section (3) shall be deposited by the breeder of the variety in the Gene Fund.

(5) The compensation granted under sub-section (3) shall be deemed to be an arrear of land revenue and shall be recoverable by the Authority accordingly.

wheat variety in India called Sonalika. Figure 1 describes the pedigree of this variety. Expanded to five generations, the variety has 31 parental varieties in its ancestry and is the result of complex combinations, crosses, back-crosses, etc. Such complex pedigrees are typical of modern varieties rather than being exceptional. Using the assumptions

Figure 1: Derivative history of Indian variety sonalika for five generations



NOTE: COUNTRY OF ORIGIN OF VARIETIES IN SHOWN IN BRACKETS. IN MOST CASES "CIMMYT" MEANS THAT THE RELEVANT CROSS WAS MADE IN CIMMYT. IN SOME CASES IT MEANS THAT THE COUNTRY OF THE VARIETY IS NOT KNOWN.

Source: The pedigree tree was prepared using the IWIS software developed by CIMMYT, Mexico.

commonly made in the computation of coefficients of parentage,[14] the contribution made by parental material from different *countries* to the evolution of the variety, when the derivative history is expanded to ten generations,[15] is given in Table 1. A single variety has contributions not only from traditional varieties in India, but also from varieties from fifteen different countries. Faced with such complex pedigrees, it is difficult to see how the PVP authorities in developing countries with limited administrative capacity can adjudicate on benefit-sharing claims. Such adjudication has to address such issues as how far back the pedigree of a variety should be traced and how contributions from varieties from other countries should be treated (for example, should foreign countries/communities be allowed to make claims for benefit-sharing?). The farmers' rights literature provides no guiding principles for estimating the relative contribution of different parental varieties.

Table 1: Contributions of different parental varieties to the Indian variety Sonalika

Name	Country	Contribution to pedigree (%)
AKAGOMUGHI	Japan	7.42
HARD RED CALCUTTA	India	7.23
RED FIFE	Canada	7.23
IUMILLO	Spain	6.64
KANRED	USA	6.64
JACINTH		6.45
LADOGA	Russia?	6.45
WHITE NAPLES	Australia	4.79
FIFE	Poland	4.79
MARIA ESCOBAR	Argentina	4.69
RIETI	Italy	3.71
KENYA 324	Kenya	3.13
SUPREZA	Mexico	3.13
B4946.A.4.18.2.1Y		3.13
YAROSLAV	USA	2.25
SQUAREHEAD	USA	1.86
IMPROVED FIFE	USA	1.86
MEDITERRANEAN	USA	1.76
TURKEY RED	USA	1.56
MARQUIS	Canada	1.27
POLYSSU	Brazil	1.17
ALFREDO CHAVES 6.21	Brazil	1.17
ORO	USA	1.17

14. Coefficient of parentage (COP) between two varieties is an index of the extent to which they share the same parentage and is used as an indicator of genetic similarity. The assumptions usually made in computing the coefficient of parentage (r) are: (a) the original ancestors of the parental varieties are unrelated (r=0); (b) a cultivar obtains equal genetic contributions from its parents; (c) all ancestors and parental lines are homozygous and homogeneous; (d) the COP between a selection from a cultivar and the cultivar is 0.75; (e) the COP between two selections from the same cultivar is (0.75)2 = 0.56; (f) the COP of a cultivar with itself is 1 (Meng et al., 1998).
15. The relative contributions made by different varieties will change with the number of generations to which the pedigree is expanded. For Sonalika, information on derivative history is available for 23 generations.

ROTE DIKKOP		0.78
ZEEUWSE WITTE	Netherlands	0.78
DARUMA	Japan	0.78
FULTZ	USA	0.78
EGYPT NA 101	Egypt	0.78
CID[a] : 5911 SID[a] : 0		0.49
CID : 143390 SID : 0		0.49
TURKEY	USA	0.49
CID : 6332 SID : 0		0.39
EDEN	Australia	0.39
SASKATCHEWAN FIFE	Canada	0.39
SPIJK	Netherlands	0.29
HOPE	USA	0.29
THATCHER	USA	0.29
STEINWEDEL	Australia	0.29
INDIAN G	India	0.29
CERES-U	USA	0.20
AGUILERA 8	Mexico	0.20
DIEHL	USA	0.20
PURPLE STRAW	Australia	0.20
GAZA	Egypt	0.20
HORNBLENDE		0.20
K39788	USA	0.10
DOUBLE CROSS	Australia	0.10
FRONTEIRA	Brazil	0.10
MENTANA	Italy	0.10
CID : 800 SID : 0		0.10
CID : 801 SID : 0		0.10
FLORENCE	Australia	0.10
FORTYFOLD		0.10
FEDERATION	Australia	0.10
ETAWAH	India	0.10
CID : 6313 SID : 0		0.10
CID : 6314 SID : 0		0.10
THEW	Australia	0.10
HUSSAR	Australia	0.10
TOTAL		**100**

Notes: a) The relative contributions of different parents to the variety have been estimated using the IWIS software developed by CIMMYT, Mexico. CID and SID refer to CIMMYT reference numbers for intermediate crosses. The country of origin of some of the parents is not known.

Secondly, these provisions assume that the returns derived by a breeder from a protected variety can be estimated at the time the protection is granted. The returns from protection generally tend to vary with the potential commercial utility and market demand for a variety, which even breeders can seldom assess accurately. It is, therefore, unrealistic to expect that an assessment of commercial potential made by the PVP authority (which must necessarily be imprecise) can be the basis for determining benefit-sharing.[16]

16. It is possible to link benefit-sharing arrangements to the actual (rather than potential) commercial performance of a variety. But administrative costs involved in tracking the commercial performance of a variety over its lifetime could be significant.

Thirdly, and most importantly, benefit-sharing arrangements may be feasible only if there are large benefits to share. Much of the empirical literature on PVP[17] suggests that it is a rather weak form of IPRs that facilitates very limited appropriability of returns for breeders. If returns from holding PVP certificates are generally modest, then returns from benefit-sharing arrangements may be very limited. PVP certificates are seldom marketed or traded and hence their private value is usually not observed. However, using patent renewal models (Schankerman and Pakes, 1986), it is possible to infer the value of plant variety rights from the economic responses of PVP certificate holders.

In almost all countries with PVP legislation, certificate holders have to pay an annual renewal fee in order to keep the certificate in force. If it is assumed that they make their renewal decisions based on the value of returns they obtain from the renewal, then the data on renewal of PVP certificates and renewal fee schedules contain information on the *private* value of PVP rights.[18] Such a renewal model implies that protected plant varieties for which protection is more valuable (for example, because it commands a larger market share) will be protected by payment of renewal fees for longer periods of time. A breeder will not renew protection for a variety for which he sees no commercial potential. The estimates of the private value of PVP certificates derived from renewal models can be used as indicators of the 'relative' value of PVP rights to supplement the data on the *number* of PVP certificates as a measure of inventive output. It is also possible to estimate how the average value of PVP certificates differs across crop groups or over time. We have attempted to estimate the private value of PVP certificates for three European countries – France, Germany and the Netherlands – which are 'mature' PVP countries, having had PVP legislation in force for more than three decades.

Methodology of renewal models

Following Schankerman and Pakes (1986), it is assumed that each cohort of PVP certificates is endowed with a distribution of initial returns, which decay deterministically thereafter. The model allows both the initial distribution and the decay rate to vary over time. It is assumed that certificate holders choose the lifespan of the certificates so as to maximise the discounted value of net returns (i.e., current returns minus renewal fees). Schankerman and Pakes show that, for a given schedule of renewal fees, these assumptions imply a sequence of renewal proportions over age for each cohort. The proportion of PVP certificates renewed in each year depends on parameters which determine the initial distribution of returns and the decay rates. Their

17. The relevant studies are Perrin et al. (1983); Butler and Marion (1985); Butler (1996); Kalton and Richardson (1983); Kalton et al. (1989); Frey (1996); Alston et al. (1998a); Jaffe and Van Wijk (1995).
18. Renewal models by their very nature can estimate only the private value of PVP certificates, which *can* be appropriated by the IPR holder. As Schankerman and Pakes (1986: 1069) observe: 'It should be emphasised that these estimates refer only to the *private* value of patent rights. We cannot address the broader question of social benefits of patent protection with the present model of renewal behaviour. The social benefits must encompass both the private value and gains in consumer surplus created by the additional R&D effort which is stimulated by patent protection (these latter gains, of course, continue after the patent has expired).' The self-reproducing nature of seed implies that breeders have considerable difficulty in appropriating returns from their innovations. The renewal model used in this article also estimates only the private returns that can be appropriated by the plant breeder or the certificate holder.

model estimates a vector of parameters, which makes the renewal proportion predicted by the model as close as possible to those actually observed.

Let us consider the case of a plant breeder who holds a PVP certificate. Let j denote the cohort of the PVP certificate and t its age so that t + j represents the year (in which renewal decisions are made). In order to keep the certificate in force, the breeder has to pay an annual renewal fee, which generally varies with the age of the certificate. Renewal fees are periodically revised, and, once revised, apply to all renewals irrespective of the cohort of the certificate. Let the sequence of renewal fees (in real terms and taking into account periodic revisions) at different ages be denoted by $\{C_{tj}\}$. A breeder who pays the renewal fee earns the return to protection in the following year, which can be denoted by R_{tj}. It is assumed that R_{tj} is known with certainty at the time the PVP certificate is granted. The breeder has to maximise the net value of discounted returns by choosing the optimal age at which to stop paying the renewal fee.

Given an assumed functional form for the distribution of initial revenues, the model derives the relationship between the predicted renewal proportions and the vector of parameters of the distribution of initial revenues and the decay rates. The functional form, which was selected to represent the sequence of the renewal proportions, was the lognormal distribution.[19] If R_{0j} (initial returns) follows a log-normal distribution, then:

$$Ln\,R_{0j} = r_{0j} \sim N(\mu_j, \sigma^2)$$

where N(.) denotes the normal distribution. Using the lognormal functional form for the distribution of initial revenues, the model yields the following estimation equation:[20]

$$y_{tj} = \phi^{-1}(1 - P_{tj}) = \frac{-\mu_j}{\sigma_j} + \frac{c_{tj}}{\sigma_{tj}} + \frac{\sum_{\tau=1}^{t} Ln\, d_{\tau j}}{\sigma_j}$$

where $\phi(.)$ is the cumulative standardised normal distribution,

$$d_{\tau j} = 1 - \delta_{\tau j} \text{ with } \delta_{\tau j}$$

being the decay rate of the initial revenues of PVP certificates in cohort j in each time period, and

P_{tj} = Proportion of PVP certificates in cohort j renewed at age t.

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19. The choice of a lognormal distribution was based on an examination of the sequence of renewal proportions for agricultural and ornamental crops in the three countries. The cumulative proportion of certificates not renewed at any age follows a skewed S-shaped pattern. The cumulative density function of the lognormal distribution is very flexible in being able to accommodate a wide range of skewed S-shaped distributions. The lognormal distribution has been extensively used in empirical models analysing patent renewal data. The other distributions that have been commonly used in patent renewal models are the Weibull and Pareto-Levy distributions.
20. For the derivation of the estimating equation, see Schankerman and Pakes (1986).

Schankerman and Pakes (1986) allow for inter-cohort differences in the distribution of the initial returns, by allowing cohort-specific variation of μ, but maintaining a common value of σ. This is equivalent to letting cohorts of PVP certificates differ by a proportional rescaling of the initial revenues of all certificates in a given cohort. They also allow decay rates to vary across decades, though it is assumed that for any time period (year) the decay rates are the same for all certificates in a cohort and across all cohorts. Thus, if the renewal data span three decades (decade 1, decade 2 and decade 3) then:

$$y_{tj} = \frac{\left(-\mu_j + c_{tj} - t_j\, Ln(1-\delta)\right)}{\sigma} - \left(\frac{\beta_1}{\sigma}\right)\sum_{\tau=1}^{t} D_{tj}^{1} - \left(\frac{\beta_2}{\sigma}\right)\sum_{\tau=1}^{t} D_{tj}^{2}$$

where it is assumed that:

$$d_{tj} = (1-\delta_{tj}) = (1-\delta)\exp\left\{\beta_1 D_{tj}^{1} + \beta_2 D_{tj}^{2}\right\}$$

and D_{tj}^{1} and D_{tj}^{2} are dummy variables such that:

$$D_{tj}^{1} = \begin{cases} = 1 \text{ if } t+j \text{ (renewal year) falls in decade 2 and} \\ = 0 \text{ otherwise} \end{cases}$$

and

$$D_{tj}^{2} = \begin{cases} = 1 \text{ if } t+j \text{ (renewal year) falls in decade 3 and} \\ = 0 \text{ otherwise} \end{cases}$$

Positive values of β_1 and β_2 indicate a decline in the rate of decay during decade 2 and decade 3 relative to decade 1.

The estimation of the value of PVP certificates was based on the above equation. The equation was estimated using non-linear least squares. One modification made in estimating the value of PVP certificates was that, instead of allowing cohort-specific values of μ, the value of μ was allowed to vary only across decades or five-yearly intervals. This was owing to the limited span of the data for some countries. The parameters of the renewal model estimated for agricultural crops and ornamentals can be used to derive the private value of PVP certificates, i.e. the returns that are appropriated by the titleholder. The present value of a single PVP certificate, denoted by V is given by:

$$V = \sum_{t=1}^{T} \frac{R_t - C_t}{(1+i)^t} = \sum_{t=1}^{T} \frac{[R_0\,(1-\delta)) - C_t]}{(1+i)^t}$$

where $R_t - C_t$ is the net return from holding a PVP certificate during age t, i is the discount rate, δ is the decay rate and T is the optimal life span of the PVP certificate based on the renewal rule discussed earlier (i.e., the certificate will be renewed only if $R_t > C_t$). The assumption of a lognormal distribution for the initial revenues (R_0) for a

cohort of certificates leads to a distribution of V. The estimates of the parameters μ, σ and δ are used to generate the distribution of V by simulation. To do this, 50,000 random variables were drawn from a lognormal distribution with the estimated values of μ and σ, and V was calculated for each one of them using the decay rate, the renewal fees applicable in any given year and the renewal rule. From this derived distribution of V, the quantiles of the private value of PVP certificates could be derived.

Value distribution of PVP certificates

We present below some estimates of the private value of PVP certificates based on a renewal model for France, Germany and the Netherlands. The estimates were prepared separately for agricultural and ornamental crops. The range of cohorts of PVP certificates, the range of years over which renewals were observed and the number of PVP certificates in all cohorts are summarised in Table 2.

Table 2: Description of data used in renewal model

	France	Germany	The Netherlands
Part A		**Agricultural Crops**	
Range of cohorts	1974-99	1988-99	1989-99
Range of years	1975-2000	1989-2000	1990-2000
Number of observations	324	88	75
Total number of PVP certificates in all cohorts	3666	1212	825
Part B		**Ornamental crops**	
Range of cohorts	1974-99	1988-99	1989-99
Range of years	1975-2000	1989-2000	1990-2000
Number of observations	283	87	73
Total number of PVP certificates in all cohorts	4836	7896	3396
Mean number of PVP certificates per cohort	186	658	308

The estimates of the private values of holding PVP certificates for the 1980 and 1989 cohorts in France and the 1989 cohort in Germany and the Netherlands are presented for agricultural and ornamental crops in Tables 3 and 4 respectively. The key feature of the value distribution for both agricultural and ornamental crops is the sharp skewness. There is a high concentration of PVP certificates with very limited economic value. For the 1989 cohort of agricultural crops, the median value of a PVP certificate was only $698 in France, $156 in the Netherlands and $1364 in Germany. For the 1989 cohort of ornamentals, the median value was $435 in France, $400 in the Netherlands and just $94 in Germany. There is a sharp rise in the value of PVP certificates in the third quartile, but most of the value is concentrated in the tail of the distribution, especially in the top 1%. For agricultural crops, only 1% of the protected varieties were

worth more than $49,844 in France, $11,093 in the Netherlands and $45,620 in Germany. For ornamentals just 1% of the protected varieties were worth more than $14,494 in France, $8,151 in the Netherlands and $2,166 in Germany. The inescapable conclusion is that the bulk of PVP certificates provide only very limited economic returns to breeders.[21] For agricultural crops, only 40-60% of PVP certificates survive for more than five years and less than 30% for more ten years. Only a very small fraction of certificates (less than 3%) survive for the full term (20 years).

Table 3: Value distribution of PVP certificates – agricultural crops (all values in constant 1998 US$)

	France		Netherlands	Germany
	1980 cohort	1989 cohort	1989 cohort	1989 cohort
Estimated parameters of renewal model				
μ	6.93	6.80	6.15	6.41
σ	1.45	1.45	0.96	0.86
δ	0.18	0.18	0.09	0.01
Value distribution				
Mean	7113.24	3708.02	863.76	4521.98
Minimum	.00	.00	.00	.00
Maximum	720521.31	413864.00	55211.94	187109.45
Percentile 25	378.18	124.22	.00	243.70
Percentile 50	1726.19	698.17	156.03	1364.29
Percentile 75	6028.70	2858.86	732.90	4422.26
Percentile 95	28079.44	15139.61	3880.55	19305.17
Percentile 99	89076.82	49844.01	11093.53	45620.16
Range	720521.31	413864.00	55211.94	187109.45

μ = Mean of the distribution of initial returns
σ = Standard deviation of the distribution of initial returns
δ = Decay rate of initial returns

21. It must be made clear that the private values of PVP certificates estimated by the renewal model reflect the returns attributable to the holding of IPRs alone. The results only suggest that the 'pure' returns to holding IPRs (and that also in the form of PVP and not patents) are modest. The overall returns from the production and sale of protected varieties may be much larger. There are other sources of economic returns in the seed business, e.g. market power.

Table 4: Value distribution of PVP certificates – ornamental crops (all values in constant 1998 US$)

	France		Netherlands	Germany
	1980 cohort	**1989 cohort**	**1989 cohort**	**1989 cohort**
Estimated parameters of renewal model				
μ	6.46	6.11	6.11	5.25
σ	1.78	1.78	1.09	0.78
δ	0.21	0.21	0.095	0.0001
Value distribution				
Mean	5942.71	3797.88	1863.15	505.60
Minimum	.00	.00	.00	.00
Maximum	1170011.03	768484.66	118026.04	23884.90
Percentile 25	120.34	57.12	33.91	.00
Percentile 50	794.98	435.30	400.00	94.21
Percentile 75	3564.38	2156.71	1662.08	492.44
Percentile 95	22455.89	14494.68	8151.09	2166.29
Percentile 99	90858.15	59430.69	22374.78	6076.59
Range	1170011.03	768484.66	118026.04	23884.90

μ = Mean of the distribution of initial returns
σ = Standard deviation of the distribution of initial returns
δ = Decay rate of initial returns

Interestingly, in France, the mean value of private returns appropriated from ornamental varieties was nearly the same as that appropriated from agricultural crop varieties. In the Netherlands, the mean value of ornamentals was more than twice that of agricultural crops. This is a surprising result, considering that the volume of seed sales in agricultural crops is of a completely different order of magnitude[22] from that in ornamental crops. PVP grants in most countries are dominated by grants for ornamental varieties. The absence of farmers' exemption in the case of ornamentals and the ease of detecting IPR infringements are likely to increase considerably the appropriability of returns from protected varieties of ornamentals. The estimates of the discounted value of returns from ornamental varieties in Table 4 show that the absolute value of returns from protected ornamental varieties matches or exceeds that of agricultural crop varieties. This may explain the large number of grants for ornamentals in most

22. No figures are available on the volume of sales of seeds or planting material of ornamental crops; however, comparisons in terms of value can be made. The estimated value of agricultural crop output in France in 1997 was approximately FF 163,481 million, while the output of flowers and ornamental plants was FF 6306 million. Given that there are a much larger number of protected varieties of ornamental plants than there are of agricultural crops, a common value of the mean of estimated returns for agricultural and ornamental crops implies that the share of the value of output appropriated by breeders is much greater in the case of ornamental crops.

countries. It also illustrates the loss of revenue to breeders, which takes place because of farmers' exemption in the case of agricultural crops.

The highly skewed distribution of the private value of PVP rights is consistent with the results of studies of the values of patent rights for industrial products. In a large study of patents granted in the UK, France and Germany, Schankerman and Pakes (1986) found that there was a dense concentration of patents with very little economic value. For the 1970 cohort of patents, they found that the median value of protection was only $1,861 in the UK, $897 in France and $5,718 in Germany (all values in 1980 US dollars). Despite a substantial rise in value in the third quartile, only 10% of all patent rights were worth more than $16,125 in the UK, $13,682 in France and $45,370 in Germany. In an important study of the British patent system based on extensive survey data, Taylor and Silberston (1970) found that, in chemicals, electrical and mechanical engineering and man-made fibres, just 20 inventions were considered to have yielded major licensing returns (i.e., licensing income of £100,000 or more). They concluded that the bulk of licence income in the fields covered is accounted for by a relatively small number of patented products and processes. The results relating to the value of PVP rights are, therefore, not surprising.

It would be of interest to compare the private value of a cohort of PVP certificates with the R&D cost of producing them. The estimated total discounted private value (at 10% discount rate) of plant variety protection for all the certificates issued in the 1989 cohort can be obtained by multiplying the mean value in Tables 3 and 4 with the number of grants made in that year in each country. We do not have the R&D cost of producing the cohort because these costs may be spread over the years leading to the development and protection of the new varieties. However, for a rough comparison it is possible to compare the private value of the 1989 cohort of PVP certificates in the three countries with the aggregate national agricultural R&D expenditures for that year. This comparison is shown in Table 5. Such a comparison, no doubt, ignores the fact there is always a lag between R&D expenditure and PVP output. It also ignores the fact that not all the private value of PVP certificates in a country accrues to nationals, while research institutions and companies may also receive the value of varieties protected abroad. Moreover, the aggregate agricultural R&D expenditures do not relate to plant breeding alone. Nevertheless, the comparison does show that the private value of a cohort of PVP certificates constitutes a small fraction (0.28%-0.72%) of the annual agricultural R&D expenditures. In the literature on the evaluation of returns from agricultural research, estimates of rates of return of 30% and above are quite common (see, for instance, the survey by Alston et al., 1998b).[23] The implication is that the private value of PVP certificates appropriated by the titleholders constitutes a relatively small portion of the overall returns from agricultural R&D.

23. These estimates relate to the total social returns from R&D and not to private returns alone. These studies also vary considerably in the elements of agricultural research expenditure that they include in the analysis.

Table 5: Private value of PVP certificates and agricultural R&D expenditure (1989) (all values in constant 1998 US$)

	France	Netherlands	Germany
Number of PVP grants made in 1989 [a]	483	751	309
Estimated mean discounted private value of PVP grants of 1989 cohort [b]	3797	1863	4521
Total estimated value of the whole cohort of 1989 (= mean value x number of grants)	1.833 m.	1.399 m.	1.396 m.
R&D expenditure on agriculture by business enterprises [i]	159.90 m.	82.52 m.	28.83 m.
Public sector agricultural R&D expenditure	601.45 m.	111.48 m.	293.49 m.
Total agricultural R&D expenditure [c]	639.57 m.	194 m.	322.32 m.
Private value of PVP rights as a percentage of total agricultural R&D expenditure	0.28%	0.72%	0.43%

Note: (a) Includes grants for crops other than agricultural and ornamental crops, e.g., such as those for horticultural crops; (b) as we do not have the mean value estimates of grants for crops which are not agricultural or ornamental crops, we have taken the mean value of agricultural crops (Table 3) or the mean value of ornamental crops (Table 4), whichever is higher, and multiplied it by the total number of grants for all crops. Choosing the higher of the two values implies that the estimated discounted private value of the cohort is biased upward. However, this only reinforces the conclusion that the private value of PVP certificates constitutes a small portion of the returns from agricultural R&D; (c) the figures of agricultural R&D expenditures shown in the table do not relate to plant breeding expenditures alone. However, it should be noted that the figures exclude R&D expenditures on 'agro-chemicals' and 'food and beverages'. Sources: (i) OECD Basic Science and Technology Statistics 1999 (R&D Expenditure by business enterprises on 'Agriculture, Fisheries and Forestry'). (ii) OECD Basic Science and Technology Statistics 1999 (Government budgetary outlays on R&D for the socio-economic objective 'Agriculture')

The above analysis shows that the private value of the bulk of PVP certificates is small, and this suggests that PVP allows only limited appropriability of returns from plant variety innovations. Large monopoly rents could possibly be a feature of protected varieties in the tail of the value distribution. What this means is that there will be a limited number of varieties that will acquire large market shares and hence earn large profits. But even in the case of varieties in the tail of the distribution, the return appropriated by the breeder is still likely to be a small fraction of the incremental

agricultural output generated through the use of the new variety.[24] A fundamental problem in giving effect to farmers' rights through compulsory benefit-sharing arrangements is that PVP allows only very limited appropriability of returns in the first instance.

Levy-based conservation funds

As noted above, approaches to farmers' rights involving IPR protection for traditional varieties or compulsory benefit-sharing are likely to pose severe operational problems (for example, in establishing ownership, assessing relative contributions of parental varieties, etc.). It is probably these difficulties which have paved the way for a third approach. This approach involves setting up centralised funds (often called gene funds) to support conservation activities, built up, *inter alia,* from a levy on PVP certificates or other IPR holdings. The Indian PVP legislation, for instance, conceives of a National Community Gene Fund that will reward farming communities for their role in conservation with funds raised from compulsory benefit-sharing arrangements –

Box 4: Gene funds to support farmers' rights: the Indian model

The provisions for the constitution of a National Gene Fund to support conservation activities and reward farming communities are as follows:

Gene Fund.

Section 45. (1) The Central Government shall constitute a Fund to be called the National Gene Fund and there shall be credited thereto—

(a) the benefit-sharing received in the prescribed manner from the breeder of a variety or an essentially derived variety registered under this Act or propagating material of such variety or essentially derived variety, as the case may be;
(b) the annual fee payable to the authority by way of royalty under subsection (1) of section 35;
(c) the compensation deposited in the Gene Fund under sub-section (4) of section 41;
(d) the contribution from any national and international organisation and other sources.
(2) The Gene Fund shall in the prescribed manner be applied for meeting—
(a) any amount to be paid by way of benefit-sharing under sub-section (5) of section 26;
(b) the compensation payable under sub-section (3) of section 41;
(c) the expenditure for supporting the conservation and sustainable use of genetic resources including *in-situ* and *ex-situ* collections and for strengthening the capability of the Panchayat in carrying out such conservation and sustainable use;
(d) the other expenditures of the schemes relating to benefit-sharing, framed under section 46.

24. For instance, in our simulation the maximum value appropriated by the breeder of an agricultural crop variety is approximately US$720,000 in France (Table 3). Let us take the case of a very successful wheat variety in the tail of the distribution, which attains a peak of market share of 10%. If we assume that a successful variety must have an incremental yield gain of 0.5% above other competing varieties, then it can be shown, *ceteris paribus*, (assuming a total wheat area of 5.11 million hectares in France, current yield level of 6.6 tonnes per hectare and a wheat price of $140 per tonne) that the annual value of incremental output would be $2.36 million and its discounted value at 10% discount rate over a period of 5 years $6.7 million. The breeder thus appropriates just 10.7% of the discounted value of incremental output. It must be remembered that even this happens only in the case of a highly successful variety.

effectively, a levy on PVP certificates. The constitution of such a fund may represent a pragmatic approach to providing incentives for conservation, separating the generation of funds from their application. However, as the application of funds is likely to be administratively determined, there is unlikely to be a direct link with conservation activities taken up by individual farming communities. In that sense, a community gene fund will not represent a 'true' rights regime.

Our concern here is with the amount of funds that can be generated through a levy on the private value of PVP certificates. To get an idea, the total discounted private value of the 1989 cohort of PVP certificates in France, shown in Table 5, was approximately US$1.83 million (in 1998 constant dollars). Even a 10% levy on breeders' returns from PVP holdings would have yielded only $183,000. No doubt, as the number of cohorts available to a country increases, the accruals to the fund may increase. But the important point is that, even in developed countries, the amounts generated through a levy on PVP certificates are likely to be quite modest in relation to the funds required for the conservation of agro-biodiversity. Once again, this is the consequence of the limited appropriability of returns afforded by PVP. The amounts generated in developing countries may be much smaller.

A levy on profits from the sale of protected varieties has also been suggested as a mechanism for raising funds for community gene funds.[25] The FAO's International Treaty on Plant Genetic Resources for Food and Agriculture (FAO, 2001) envisages an international fund which will be financed through 'an equitable share of benefits arising from the commercialisation' of a crop variety that incorporates genetic material obtained from the multilateral system (Falcon and Fowler, 2002). The implementation of such a levy would require a complex and expensive monitoring system to track the flows of plant genetic resources through a maze of cross-country transactions (involving individuals, private and public research institutions and companies) and establish the contribution of PGR from specific sources to new (protected) varieties. It appears unlikely that developing countries will acquire the necessary monitoring capabilities in the near future. The administrative costs of implementing such a levy would also probably be high, as it would involve monitoring variety-wise sales/profits at the national and international level for all protected varieties over their lifetime. Moreover, as Falcon and Fowler (2002) argue, royalties assessed as a percentage of profits from seed sales of particular new varieties constitute a narrow base for resource generation. It appears that conservation funds will have to rely mainly on other sources of funds (for example, budgetary appropriations from governments or international donors) if they are to make a substantial impact. The issue of developing transparent norms for rewarding farmers/farming communities from these funds will also pose many challenges.

25. In the context of the Indian PVP legislation, a levy on the *sales* of protected varieties has been discussed (Swaminathan, 1996). The domestic seed industry does not appear to be averse to the idea. The extent to which such a levy on sales would be absorbed by seed companies or passed on to farmers in the form of higher prices would depend on market conditions.

Consequences of farmers' rights provisions

Irrespective of whether farmers' rights bring large benefits to farming communities, they will have important implications for institutional plant breeding. Both private and public research institutions have previously drawn freely on PGR conserved by farmers for the development of new varieties. Farmers' rights provisions are likely to have a significant impact on the development cost of a new variety as well as on the transaction costs of getting it protected. If access to PGR held by farming communities requires prior informed consent and also payments (for example, licensing fees), then new variety development will almost certainly slow down[26] – especially when there are no established procedures for obtaining prior informed consent. Plant breeders generally try out a large number of complex combinations and crosses of different parental varieties in the process leading to the development of a single commercially successful variety. If access to virtually every parental variety has to be negotiated and paid for, then it is easy to see that the development of new varieties will be adversely affected. If farmers' rights over traditional varieties extend in perpetuity, then breeders' access to these varieties will also be permanently restricted. Transaction costs for obtaining protection will increase because breeders will be required to establish that all their parental material has been legally obtained with prior informed consent. Breeders will also be required to go through lengthy procedures for the determination of benefit-sharing and compensation claims. In fact, breeders are likely to expend considerable energy in defending their varieties against the claims that will probably be put forward by NGOs representing farmers.

Benefit-sharing with farmers (or with the public sector)[27] will clearly reduce the economic returns accruing to breeders from protection. If, as we have seen above, the returns appropriated by breeders under conventional PVP systems are limited to start with, then the impact of benefit-sharing arrangements will be merely to dilute the incentive effects of PVP for innovation and investment in plant breeding. This is perhaps not what developing countries intend. If the intention is to encourage private investment in plant breeding, then there is a need to reinforce IPRs by facilitating better appropriability of returns. Other measures intended to make farmers' rights effective, such as compulsory disclosure of pedigrees (which many seed companies, for example, would like to treat as trade secrets to prevent piracy) and compulsory deposit of seeds of parental varieties,[28] are also likely to discourage breeders from using PVP as an instrument of protection.

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26. It could be argued that breeders mostly access PGR through *ex-situ* collections rather than directly from farmers. However, if farmers' varieties and materials are protected through farmers' rights, then access to these materials in *ex-situ* collections will also be restricted.
27. The Indian legislation provides retrospective protection to public sector varieties, with the intention that the public sector should be able to derive benefits from new varieties developed by the private sector through the operation of the essential derivation clause.
28. Deposit of samples of the seeds of the variety sought to be protected (e.g. a hybrid variety) is usual in PVP because it fulfils the reproducibility requirement under IPR law. However, deposit of samples of seeds of parental varieties (which may be required for verification of benefit-sharing claims) poses commercial risks for plant breeders if the confidentiality and security of the samples deposited with a PVP authority are not ensured.

In summary, increased development and transaction costs, lower returns owing to benefit-sharing and compulsory disclosure of commercially sensitive information entailed by farmers' rights provisions are likely simply to dissuade institutional plant breeders from seeking protection. The fundamental objective of PVP may therefore get defeated. Breeders will either switch to stronger forms of protection like patents (if available)[29] or rely on technological solutions (for example, rely on hybrids, which require farmers to purchase fresh seed every year or maybe even rely on 'terminator' technology). Farmers' rights provisions will also tend to put institutional breeders and farmers in adversarial positions, at a time when participatory plant breeding approaches are being increasingly advocated.

Conclusion

The conservation argument and the equity argument make a strong case for recognising and rewarding the role of farmers as conservers and enhancers of agro-biodiversity. Conventional PVP systems *are* iniquitous because they reward the innovations of institutional plant breeders, while providing no reward to those who provide them with their critical resource. However, the extension of an IPR regime to farmers' traditional varieties through novel adaptations of IPR law and mandatory benefit-sharing arrangements may not be the appropriate way to redress this imbalance. IPR-based approaches to farmers' rights are not only likely to involve severe operational difficulties, far beyond the present administrative capacity of developing countries to handle; they are also unlikely to provide significant returns to farming communities. Superimposed on conventional PVP systems that allow only limited appropriability of returns, farmers' rights provisions will further dilute the incentives for innovation provided by PVP to institutional plant breeders. This may not be a desirable outcome for developing countries. Conservation projects supported by community gene funds may be a better way to address concerns regarding the preservation of agro-biodiversity. But again, the expectation that levies on breeders' IPR-related returns can be a major source of revenue for these funds is unrealistic.

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29. In the United States there has been a noticeable move away from PVP to stronger forms of protection like utility patents over the last five years.

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