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TOWARDS A CONCEPTUAL MODEL OF OPTIMAL INVESTMENT IN THE CONSERVATION OF AGRICULTURAL GENETIC RESOURCES

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ABSTRACT: This paper develops an economic model of investment in the conservation of agricultural genetic resources. For a putative national decision maker investing in conservation across species, it proposes an approach of maximization of returns from conservation subject to a budget constraint. Returns are a function of the value of the conserved resources and the costs of conservation. The value of the resources depends on both supply and demand factors, both domestically and internationally. Demand factors include the current domestic and international of values of the production of different species, adjusted for trend changes. National capacity to exploit genetic resources is also proposed as a consideration. Supply factors include the amount of unique genetic variability at the national level, the rate of its loss, "genetic erosion", and the amount of available internationally conserved genetic variability.

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Genetic resources are a key raw material for improving agricultural productivity, either through conventional breeding or through biotechnology assisted approaches. Agricultural genetic resources are especially important for developing countries whose economies and employment are relatively more dependent on agriculture. Moreover, much of the world's wealth in genetic resources comes from developing countries, many of which have a greater endowment of genetic resources than scientific capacity for leadership in biotechnology research. Thus for many developing countries, genetic resources may be the asset that enables them to participate in benefit sharing from biotechnology research partnerships. Consequently the conservation of agricultural genetic resources is widely perceived as important and many substantial recurring national and international investments are being made in genetic resources conservation, and these have a direct impact on countries' capacity to take advantage of biotechnology.

This paper attempts to develop a simple decision tool to assist policy makers responsible for making public sector choices about investment in conservation of agricultural genetic resources.Even with current often burdensome investment levels for many developing countries in light of other pressing needs such as health and education, not all agricultural genetic resources are being securely conserved and genetic erosion continues. In the face of the scarce resources available for the conservation of agricultural genetic resources compared to the magnitude of potential investment that could be desirable, there is a need for a systematic approach to thinking through what optimal investment in genetic resource conservation may be. Of course if resources were not limiting, then the policy recommendation would simply be to conserve all agricultural genetic resources. This does not, however, reflect the actual decision framework facing genetic resources policy makers and national treasuries financing this investment. Moreover, in the absence of an appropriate decision making framework, there is the risk of failing to conserve the most valuable genetic resources as well as over investment to conserve less critical resources. Choices are in fact already being made about which genetic resources to conserve, but there is a lack of analytic framework to assist in such decisions.

Past research has examined various aspects of the economics and policy of agricultural genetics resource conservation. Optimal investment to minimize the loss of genetic diversity among livestock breeds has been modeled (Simianer et al 2003). Costs of genebank management have been extensively studied (Burstin et al 1997; Epperson et al 1997; Koo et al 2003). The marginal net benefit to screening an accession in a gene bank has been estimated (Zohrabian et al 2003). Extensive work on conservation of individual wild species, mostly through contingent evaluation or willingness to pay studies have been reviewed (Nunes et al 2001). There does not, though, appear to be a previous study on optimal investment at the national level in agricultural genetic resource conservation to enable gene bank managers or biodiversity policy makers to make choices about which and how much agricultural resources to conserve under conditions of financial limits.

Thus, the purpose of this analysis is to develop a simple, practical framework that provides a conceptual model of optimal investment in the conservation of agricultural genetic resources. The model is developed to reflect the choices of a national decision maker to invest in genetic resources conservation of different crop species typically either with a long history of domestication in the country, with wild ancestors and relatives, or introduced crops cultivated long enough to develop unique land races or become a secondary source of diversity.

Such a national decision maker faces choices about which crop species to conserve, and how much to invest in the conservation of different crop species. The national decision maker can be envisioned as a treasury or ministry authority deciding how much to invest in the conservation of agricultural genetic resources or it could be the leader of a national gene bank or biodiversity authority actually responsible for developing and implementing plans for agricultural genetic resource conservation. These investments could include in situ conservation interventions, or making collections of germplasm and storing this germplasm long term in ex situ gene banks through various means including field collections, cold storage, tissue culture etc. This is not intended as a decision framework for a private sector biotechnlogy or breeding firm for the management of its working collection, though conceivably some of the consideration here might also be of interest to them.

This framework includes costs, so it includes making decisions among alternate means of genetic resource conservation. The fundamental decision variable in the framework, though, is how many resources to invest in conservation for different crops. This framework is not designed to look at other economically important genetic resources such as forestry, fisheries, livestock or genetic resources of potential value in non-agricultural uses such as pharmaceuticals. Since this framework is based on the economic use value of agricultural genetic resources, it does not consider such aspects as existence values. Nor are issues like seed market regulations, intellectual property law, or biosafety regimes part of this framework. Likewise, though private sector biotechnology or breeding firms can be direct beneficiaries of current or past genetic resource conservation efforts, this paper does not explore either how benefits of costs might be shared between these actors and others, for example, through farmers'rights.

Agricultural genetic resources differ substantially from other biodiversity. In the first place, by their very nature as the basis of agriculture, they have a use value of a different order of magnitude than general biodiversity in natural ecosystems. Agricultural genetic resources are thus much more of a direct economic resource than biodiversity in natural ecosystems, and this pre-eminent status as an economic resource makes the economic analysis of their conservation more compelling. Secondly, while biodiversity in natural ecosystems essentially has an autonomous existence outside human interference, and typically requiring no more than non-intervention by humans for its continued existence, agricultural genetic resources have undergone an extensive process of human intervention through domestication, selection and often scientific breeding. Consequently, these agricultural genetic resources can by and large survive only through active human intervention to conserve them, either through ongoing use in agricultural systems (in situ conservation) or through formal conservation through collection and storage in genebanks (ex situ conservation). Because agricultural genetic resources so clearly have an economic use value, and their conservation so obviously depends on active human decisions that involve costs, an economic approach to the analysis of the conservation of agricultural genetic resources seems particularly appropriate, perhaps more so than would be the case for the biodiversity of naturally occurring ecosystems. In any case, the approach of this analysis is explicitly economic, considering the costs and benefits of their conservation, where the benefits are derived from demand and supply factors.

Broadly speaking, the approach taken here is that the optimal investment in conservation of the genetic resources of a given species rises with the economic importance of the species, both in the country investing to conserve the genetic resources and the species' global economic importance. Genetic resources need to be seen not only as something with use value in the country of origin, but with an internationally recognized system of property rights in genetic resources, they may also be a source of export earnings and this increases with an increase in the economic importance of the crop globally as well as in the country of origin. Investment in genetic resources conservation for a species also depends on the amount of indigenous genetic resources and the amount of foreign genetic resources. The greater the amount of unique indigenous genetic resources compared to the global total genetic diversity of the species, the greater the likely value of national genetic resources. Likewise, the greater the risk of genetic erosion in a species, the higher the optimal value of investment in conservation will be. Finally, the costs of conservation, whether in situ or ex situ, will vary by species, and the value of conservation has to be optimized subject to the costs of genetic resources conservation. The logic behind the variables included in the model is elaborated below and a framework to express the model is developed.

First some key assumptions underlying this analysis will be noted. Then the demand, supply and cost factors that constitute the elements of the proposed framework will be discussed. A formal model for investment in agricultural genetics resource conservation is next specified. Finally the summary and conclusions considers the potential feasibility of utilizing this model further and notes some of the major implications that can be drawn from its logic.

Assumptions: In this work it has been assumed that the value of a gene lays in its potential use in the crop in which it originates. With conventional breeding, including molecular marker assisted selection, this is of course generally the case. Rice genes are used for rice improvement, so that the value of rice genes are closely related to the value of the rice crop. In the case of transgenic crops, where genes can in principle be moved from one species to another, with, for example, sorghum genes being used to improve drought tolerance in rice, the value of genes can lay outside the crop of origin. Currently, however, transgenic modification of crops remains only a part of total crop improvement effort. Particularly when regulatory and intellectual property costs are taken into account, there are in many cases continuing advantages to conventional crop breeding which in any case remains the mainstay of genetic improvement in most developing countries to this day. Thus, in these circumstances the current economic value of genes in many cases may still be principally in the crop of origin.

Yet transgenic approaches to crop improvement are increasing even in developing countries, and the effectiveness of these techniques should be increasing over time, and costs should be expected to decline. The implications on genetic resource conservation of transgenic approaches to crop are complex. For gene mapping, information from the target or related species, for example among legumes or cereals, is often the most valuable. Desirable genes may likewise be obtained from the target or related species. For instance, the source of the gene for delayed ripening in transgenic tomato actually came from tomato itself. However, in most other cases to date, transgenic crops have obtained desired traits through transformation with genes from other species, most often microbial species. In the case of some of the most widely used transgenic crops today, for both *bt* insect resistance as well as herbicide tolerance, the genes conferring the desired traits were derived from bacteria. Similarly, resistance genes in papaya and other horticultural crops have been obtained from the viral pathogens themselves. In this context, assessing the potential value of genetic resources moves analytically to another level. With the possibility of exploiting genetic diversity from any organism in crops, the issue would then seem to be more of conserving biodiversity in general. Without discounting this, this paper has taken the narrower focus of attention of the conservation of genetic resources in agricultural crops on the premise that these remain the major resource from crop improvement. While the growing importance of non-agricultural diversity for crop improvement cannot be excluded, the analysis here focuses on the still important decisions about conserving agricultural genetic resources.

Investment in the conservation of agricultural genetic resources in this paper refers both to the costs of ex situ conservation, including both collection and conservation, and costs of in situ conservation where they take the form of an explicit investment by a conservation agency, that is, excluding autonomous and independent decisions by farmers to maintain land races for their ongoing use in the absence of any intervention of any conservation entity.

The proposed framework emphasizes the international dimensions to genetic resources conservation. International partnerships offer the prospect of benefit sharing between countries of origin of genetic resources and countries that utilize them. Such partnerships could be of mutual benefit to gene rich tropical countries that are often economically and technically disadvantaged as well as benefit to wealthy technically advanced countries whose commercial agriculture is highly dependent on introduced genes. There is a legal framework that in principle is conducive to such partnerships. The Convention on Biological Diversity, from the 1992 Rio earth summit, vests ownership of genetic resources in the country of origin while the 2004 International Treaty on Plant Genetic Resources for Food and Agriculture entails a clear commitment to benefit sharing. This emerging legal framework has, however, been proceeded by a long period of numerous examples of the wealthy technically advanced countries taking advantage of genes from poor countries without compensation. It would not be expected that these technically advanced and politically powerful countries would be overly keen to pay for resources that were formerly free for their open use. At the same time, many poor countries are not yet fully confident that their rights to their genetic resources can be protected. Despite these problems, the fact remains that international partnerships could be of mutual benefit. Attaining these benefits depends on an effective system of property rights in genetic resources as well as technology, and this paper assumes that this system can be as effective as envisioned in existing international conventions.

Elements of a Decision Framework: Here a framework for decision-making on investment in conservation of agricultural genetic resources is proposed. It is designed to take decisions at the national level about how much to invest in the conservation of genetic resources of different agricultural species. The framework is explicitly economic, maximizing benefits net of costs. Benefits are also derived from an economic framework, with the central measure of benefits being the economic value that can be derived agricultural genetic resources. The framework proposes to assess these economic benefits from a perspective that considers three demand side factors, and three supply side variables. The demand side variables which essentially approach the value of genetic resources through the demand for their use are the potential value of these genetic resources in domestic production in the decision making country; the potential value of these genetic resources for export; and the demand for actually using genetic resources domestically as measured by capacity to add value through breeding, either through biotechnology approaches or through conventional means. The supply side variables which essentially approach the value of genetic resources through their scarcity are the amount of unique genetic diversity in a country; the availability of alternative suppliers of conserved genetic diversity; and the rate of loss of national genetic diversity in the absence of a conservation effort.

From an economics perspective, and particularly in the context of conventional approaches to breeding, the value of agricultural genetic resources is to some significant extent related to the underlying value of the agricultural commodity. Genes for a billion dollar crop would be expected to be more valuable than genes of a million dollar crop since they can more directly contribute to the productivity of a more valuable crop. Genes to increase the productivity or reduce crop losses in rice would be more valuable than similar genes in a lower value crop such as pearl millet since they would have their impact over a greater total of production or total value of production. Thus in the first instance, optimal investment in genetic resources for a country would be in some sense proportionate to the value of production of the crop in that country. This would conventionally be expected to be a strong relationship or an important decision factor for a country and it has the advantage of being an easily observable variable for decision makers.

There are two complicating factors to such an approach. The first is that the competitive advantage of a crop in agriculture can change over time. Today's minor fruit crop could be a major commercial crop in the future as the case of kiwi fruit illustrates. Likewise, today's major commodity staple could go into substantial decline due to increased competition, as for example sugar beet in Europe. The shifts away from maize and towards horticultural crops in Mexico with its entry into NAFTA illustrate how the economic importance of crops, hence the putative value of their genetic resources, can change. It should not necessarily be to difficult, though, to observe or forecast trends in competitive advantage that would lead the future relative value of crops differ from their current relative values.

A more serious objection to the criteria of current value or trend adjusted expected value, is that biotechnology makes plant improvement increasingly less limited to using genes from the gene pool of target species. Economically desirable traits may be found in almost any specie. As noted above, from this perspective general conservation of biodiversity may become ever more important. However, from the point of view of existing conservation systems charged with husbanding agricultural genetic resources, there is still a case for giving greater weight among agricultural species to those with higher current values, if for no other reason than that they are more valuable to conventional breeding programs.

Given that genetic resources are property of the nation, there would seem to be additional potential value proportionate to the value of the genetic resources of a particular crop globally, not just in the country of origin. This would be assuming an international market in agricultural genetic resources. Recently in June 2004 the International Treaty on Plant Genetic Resources for Food and Agriculture came into force. Under this treaty the signatories agree to open exchange of many important agricultural commodities (exceptions include groundnuts, tropical forage species etc.) under conditions that include provisions for benefits sharing, including benefits from the commercialization of genetic resources. Thus even under this open system of exchange of genetic resources, there is some potential for countries to benefit economically from the use of their genetic resources in other countries. Consequently, optimal investment in genetic resources conservation would depend not only on the national value of production of a given crop, but also the global value of the crop. Although previous work has shown that except in countries with wealth in genetic resources and a low value of domestic production compared to international production, the domestic use value of genetic resources is typically greater (Pachico 2001), nonetheless international opportunities should not be totally discounted. In many circles there is considerable fear of such international partnerships to share the benefits of genetic resources on the basis of unequal power relations between the parties involved (e.g. small countries sometimes governed by corrupt elites vs. large multi-national corporations), but with proper management there can in some cases be significant benefits to be attained.

The third element to the demand side of the conservation of agricultural genetic resources is the influence of the capacity to add value to genetic resources. Basically the logic is that where there is a significant capacity to add value to genetic resources, either through biotechnology or conventional breeding, there will be higher returns to conservation and therefore more investment in conservation is optimal. This can in turn be considered from two points of view, national capacity to utilize genetic resources and international capacity. From a strictly domestic national perspective, countries with a strong genetic improvement capacity should invest more in genetic resource conservation because, all else being equal, they can earn higher returns from these resources. It should be noted that national biotechnology and breeding capacity properly includes private sector capacity as well as public sector. Increasingly the private sector is making growing investments in genetic improvement so this private capacity needs also to be taken into account in assessing national capacity to utilize genetic resources.

Conversely, a purely economic analysis would suggest that the returns to genetic resource conservation would be depressed in countries without strong genetic improvement capacity. While such lower returns from conserved genetic resources could seem to imply less incentive to invest in conservation, a more positive lesson for conservation advocates to draw from this logic is that investment in increased capacity to use genetic resources would increase the domestic demand for conservation. There are thus positive synergies between investment in biotechnology and genetic resource conservation. This logic could be extended along the lines that although current capacity to use genetic resources may be low, it could be higher in the future, thereby justifying greater current conservation investment, though caution needs to be exercised about the reliability of such long term estimates or their present value.

Capacities to use genetic resources are not, however, limited just to the decision-making nation in this framework. International capacity to use genetic resources is also an important consideration. Although a country itself may not have state of the art capacity in biotechnology, such capacity does indeed exist internationally, opening the prospect for international partnerships. The potential of mutual benefit from such partnerships increases the returns to genetic resources conservation beyond what they would be from a purely domestic perspective. It would seem likely that the derived demand for domestic conservation of genetic resources from the international capacity to use them would tend to largely coincide with the international importance of agricultural species. In a sense, therefore, the existence of international capacity to add value to genetic can almost be taken as given, but it can safely be assumed that it is basically aligned with the international importance of different agricultural species. Thus, this factor is essentially the same as the second element noted above, the global value of a crop, so that a new element does not have to be added here.

These first three variables are effectively part of the demand for genetic resources. Also important to decisions on genetic resources are supply factors. These include the amount of unique genetic variability in the country; the availability of alternative sources of genetic variability; and the risk of genetic erosion, that is the depletion of currently existing variability. Each of these factors will be discussed briefly in turn.

Optimal investment in conservation of genetic diversity is not directly proportional to the amount of genetic variability in a country. That there is little genetic variability for a given crop, or that there is a great amount of genetic variability does not have a direct bearing on the value of this genetic variability. Rather, it is the amount of unique genetic variability in a country that is critical. More precisely, it is the amount of unique variability compared to the global variability. The greater the proportion of global genetic variability for a crop in a country, the greater is likely value of this variability. If a country has only a small amount of variability for a given crop compared to what exists elsewhere, it is more likely that the genetic variability it has is not unique and is available elsewhere, and is therefore less scarce and less valuable. A country which has a large proportion of the genetic variability for a crop, is likely to have a wealth of genes that are not available elsewhere and therefore are more likely to be scarce and therefore more valuable. The agronomic or economic importance of genes, is not of course, simply related to total genetic variability. It is possible that there are relatively unique environments for a specific crop that lead to the existence of economically valuable traits, for example, unusual climatic conditions for a crop which confer adaptability that is not found within the bulk of the variability for that crop. Though not completely impossible, it is nonetheless very difficult except in some specific situations to measure or predict with any degree of accuracy from whence useful genes may come. Thus, it would seem that the most useful initial approach would simply estimate the total amount of genetic variability for the different crops in a country, and compare this with the total global variability. Even these estimates are far from straightforward to make.

A second supply factor, not totally unrelated to the previous variable, is the amount of openly available genetic variability that is conserved elsewhere. There are large collections of genetic resources for many important crops that are publicly available, for example, in the collections of the Future Harvest Alliance Centers of the CGIAR. The more genetic variability available for a particular crop through such public sources, the less incentive a country faces to conserve the genetic diversity of that crop. Rather than undergoing the expense of conserving the variability for itself, a country can effectively transfer this burden to a third party while still maintaining access to the genetic variability. Although these institutions have a three decade long record of making freely available the genetic resources which they hold in trust, nonetheless there is the potential risk that some time in the future these genetic resources may no longer be freely available. While the risk currently appears minimal that such sources of conserved genetic resources will either fail to conserve their collections, or will in the future deny access to them, it might perhaps be less unlikely that under the framework of the International Treaty on Plant Genetic Resources for Food and Agriculture, countries that are the original sources of germplasm in these collections, might insist in the future on some sharing of the benefits from the use of their genetic resources. This in turn would make it slightly more attractive to incur the current costs of genetic conservation rather than risk what could be larger future costs. Despite these considerations, overall the risk of not having free access to these genetic resources in the future would appear to be fairly low. Thus, the existence of reliably available genetic resources, conserved at the cost of third parties, would indeed seem to be a rational economic incentive for a country to invest less in the conservation of those genetic resources. All else being equal, it would be more attractive to conserve genetic resources that are not otherwise available.

Genetic erosion is the disappearance of genetic resources caused by many factors among which are changes in farming systems or markets for land races, or by factors such as land use change, habitat destruction, or climate change for wild ancestors or relatives. Genetic erosion reduces the amount of existing potentially useful genetic resources. All else being equal, the greater the rate of genetic erosion for a given species, the greater the incentive to conserve these genetic resources to avoid their loss. Where genetic erosion is low, there may be a less pressing need to explicit investment in genetic resource conservation since greater reliance can be placed on autonomous in situ conservation, reducing the need for costly investment either in ex situ or subsidized in situ conservation efforts. While the logic may be clear, in practice the measurement of the rate of genetic erosion is far from straightforward and often such information is highly imprecise and impressionistic. Clearly, though, where there is an obvious high risk of genetic erosion, the incentive for investment in conservation to preserve potentially valuable genetic resources becomes greater.

Finally, besides the demand and supply side factors that lend value to agricultural genetic resources, costs have to be a consideration in an economic analysis of investment in conservation of agricultural genetic resources. As discussed above, because agricultural biodiversity largely exists only through human activity, costs almost inevitably have to be incurred to insure their conservation. There is an emerging literature on costs of the conservation of agricultural genetic resources, and comparisons show that these conservation costs vary by technique, and can vary by crop. Although it is not the purpose of this paper to enter into an extensive analysis of conservation costs or alternatives, nonetheless, a model of optimal investment in agricultural genetic resource conservation would be incomplete without explicit consideration of cost factors. Perhaps the most significant practical implication of cost in the decision framework is the implication that, holding everything else constant, it is rational to conserve more genetic resources of species whose conservation costs are less. In the context of having limited resources for conservation activities, which is indisputably the case, then this would indeed be a rational approach. More positively, cost considerations point to the great importance for the need to improve conservation techniques to make them more effective and less costly. Improvement in genetic resources conservation techniques that reduce costs, perhaps through research, can have a major impact on the amount of genetic diversity that can be conserved in the face of limited resources.

Towards a Model:

For a national decision maker investing in the conservation of crop i, the returns to that investment, R_i, would be a function (1)

(1) $R_i = f(VN_i, VW_i, BC_i, DN_i, DW_i, DE_i, C_i)$

where

VN_i = Value of production of crop i in the country

VW_i = Value of the production of crop i in the rest of the world

BC_i = Biotechnology and breeding capacity for crop i in the country

DN_i = Diversity of crop i in the country

DW_i = Diversity of crop i in the rest of the world available for use in the country

DE_i = Rate of genetic erosion in crop i in the country

C_i = the cost of conserving the genetic resources of crop i

so that the investment decision for a national decision maker responsible for agricultural genetics conservation across all crops in a country would be

(2) Max $\Sigma_i^n\ R_i - C_i$

subject to

(3) $\Sigma_i^n C_i \leq I$

where

there are n crops

I is a budget constraint for investment in agricultural genetics resource conservation in the country.

Summary and Conclusions: This paper argues for an economic analysis of investment in the conservation of agricultural genetic resources. For a putative national decision maker investing in conservation across species, it proposes a standard approach of maximization of returns from conservation subject to a budget constraint. Returns to conservation are a function of the value of the conserved resources and the costs of conservation. The value of the resources is seen to depend on both supply and demand factors, both domestically and internationally. Demand factors include the current domestic and international values of the production of different agricultural species, adjusted for trend changes in these values. In addition, the national capacity to exploit genetic resources is also proposed as a consideration. Supply factors determining the value of genetic resources at the national level include the amount of unique genetic variability at the national level, the rate of its loss, "genetic erosion", and the amount of available internationally conserved genetic variability.

Assuming for the moment the acceptance of the logic of this framework, its utility would then become largely a function of the practicality of implementing such a model. Costing genetic resource conservation has become essentially a routine matter. Measuring the values of domestic and international production is pretty straightforward. One approach to estimating national capacity to add value to genetic resources would be to utilize data on current research investment by crop, which should be available in many countries. Nor would it seem to excessively difficult to devise a categorical approach that would capture major differences in research capacity across crops. In sum, the demand factors would not seem to present major difficulties. Interestingly, measuring these more socio-economic demand variables may be more tractable than measuring the somewhat more biological supply side variables. The amount of existing genetic variability nationally or globally for a species is only imperfectly measurable. It could be possible to make some estimates based on global collections of genetic resources where these exist. Even this approach is limited by the fact that such global collections are not random samples of genetic diversity but were intentionally collected on various criteria. Nonetheless some rough estimates should be possible and in principle these could be supplemented by expert opinion. The rate of genetic erosion is apparently less well know, though there is some literature on the topic that could provide a basis for making some estimates by crop by country, though such estimates would necessarily be imprecise. The amount of internationally conserved genetic variability is quite well documented. Thus, though not without some difficulties, it would appear that in principle the underlying variables of this model could be measured sufficiently well. Estimating the parameters of these variables in an optimal investment model would of course be an additional challenge. If data were collected from a number of countries, which would not be totally impossible, then some parameter estimates could in principle be made. Clearly there is a feasible research agenda here that might well be justified by the importance of the issues involved.

Even without fully estimating this model, it would seem likely that a less formal approach based on this framework could still provide a rough guide for decision makers. While not providing a full estimate of optimality, using this framework as a decision check list at the national level could well lead to improved decision making in genetic resources conservation investment. It would not be overly difficult to try such an approach.

Further extensions to augment the model could be made. For example, the model currently does not consider distributional issues. Where certain crops are more important for the poor, the returns from these crops could be more heavily weighted to reflect such distributional objectives.

Some implications for the conservation of agricultural genetic resources can be drawn from the logic of the framework. Among these implications are the following:

-Invest in conservation in rough proportion to the domestic economic value of the crop

-Opportunities for international partnerships can confer greatly increased values on domestic genetic resources.

-Where national financial resources are especially limiting, and large public international gene banks exist, it may make more sense to invest relatively more in the conservation of domestic genetic resources for other species.

-It is important to identify species most at risk of genetic erosion, especially from among those of high economic value domestically or internationally

-Strengthening national capacity in biotechnology and genetics raises the returns to conservation and improves bargaining power in international partnerships

-Innovations to minimize conservation costs can be most useful

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