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PARTICIPATORY TECHNOLOGY DEVELOPMENT WITH RESOURCE-POOR FARMERS: MAXIMISING IMPACT THROUGH THE USE OF RECOMMENDATION DOMAINS

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Abstract

Participatory technology development (PTD) has been advocated as a way of increasing the likelihood that technologies developed will be suitable for resource-poor households (RPHs). However, PTD is a resource-intensive approach, and it has also been argued that it is an expensive one, on the grounds that the high degree of heterogeneity among RPHs and their farming systems means that the number of them adopting any particular technology will be small. In this paper, with reference to case studies of three livestock technologies developed using participatory approaches, we make preliminary estimates, through the use of recommendation domains (RDs), of the potential number of beneficiary RPHs. We conclude that in all three cases the RDs could be large, i.e. more than one hundred thousand households. Our more general conclusion is that PTD can be cost-effective provided that various conditions are satisfied. These are: PTD should be based on effective diagnosis and research site selection; 'product champions' for the technologies should be supported; RDs should be identified; information about the technology should be availed to key agencies in the RD; and resources should be made available to disseminate the technology to households in the RD.

Research findings

- *Technologies that have been developed with a small number of resource-poor households can have large recommendation domains.*
- *The identification of recommendation domains can be a valuable tool in: (a) developing targeted dissemination strategies for specific technologies; and (b) prioritising technologies for dissemination.*

Policy implications

- *Development agencies undertaking PTD, particularly NGOs, should broaden their horizons and put greater effort into promoting effective technologies they have developed with farmers and livestock-keepers to the majority of potential adopters.*
- *When developing their dissemination strategies, development agencies should consider using recommendation domains to identify the most promising areas for adoption of effective technologies that have been developed.*
- *Provided sufficient attention is given to scaling up strategies from the outset, PTD can be highly cost-effective for developing technologies for the resource poor and deserves to be more widely used by both research and development agencies.*

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CONTENTS

Acronyms

ASAL	Arid and Semi-Arid Land
CAZRI	Central Arid Zone Research Institute, India
CIMMYT	International Maize and Wheat Improvement Center
DAREP	Dryland Applied Research and Extension Project, Kenya
FPR	Farmer Participatory Research
FSR	Farming Systems Research
HDRA	Henry Doubleday Research Association, UK
KARI	Kenyan Agricultural Research Institute
NRI	Natural Resources Institute, UK
PRA	Participatory Rural Appraisal
PTD	Participatory Technology Development
RD	Recommendation Domain
RPF	Resource-Poor Farmer
RPH	Resource-Poor Household

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1 INTRODUCTION

The historical and institutional context for PTD

During the 1970s and 1980s there was growing recognition that agricultural research had primarily benefited resource-rich farmers, and that the main reason why resource-poor farmers (RPFs) had been slow or unable to adopt recommendations was that the technologies were not appropriate for them (Collinson, 2000; Chambers et al., 1989). This recognition contributed to the emergence of the farming systems research (FSR) movement in the 1970s. This was soon followed, and to some extent paralleled, by the growth of farmer participatory research (FPR) and participatory technology development (PTD) during the 1980s and 1990s. PTD put much more weight on participation than FSR had and gave less attention to the issue of rationalising limited national research resources (Collinson and Lightfoot, 2000). Some PTD proponents saw FSR as overly reductionist in approach, unable to address the challenges of complex and diverse systems.

The move to make research more relevant to resource-poor farmers (whether as FSR or PTD) was strongly supported in less developed countries through donor-funded projects and programmes. Some efforts were made to institutionalise systems-based and participatory approaches within the national research systems of less developed countries. These efforts met with varying degrees of support from within the national research organisations, having greater success where the support was stronger. Broadly speaking, institutionalisation efforts were more effective in the national systems where the conditions (internal and external)[1] for the development of technology were less favourable, hence research managers and researchers were more open to exploring new approaches. Thus, in countries like India, where the Green Revolution had a major impact on agricultural productivity and national development, the national research systems felt more secure with conventional approaches to agricultural research, and less need to experiment with alternatives. By contrast, in Africa, where the Green Revolution effects were patchy, and suffered major set-backs under policy reform in the direction of greater liberalisation of the agricultural sector, the need to try out alternative approaches was more widely accepted.

Weakness of PTD as practised

A noted weakness of FPR/PTD has been its limited breadth of coverage (Farrington, 1998). Some people might argue that this does not matter; and that if it succeeds in empowering small numbers of farmers, and improving their capacity to experiment and adapt, this is adequate justification for the high resource costs involved in this relatively intensive approach. Others, including ourselves, believe that it is important to find ways of increasing the breadth of coverage, in order to maximise the benefits. This leads into discussions about design and implementation, which we raise here. It has also been argued, however, that there are *inherent limitations* on the number of RPFs that will be able to adopt any given technology due to the diversity of conditions. Proponents of this view argue that it is more important to 'scale up' the PTD approach than it is to scale up a particular technology – which is seen as 'supply driven/transfer of technology/top-down' and therefore inappropriate (van Veldhuizen et al., 1997; Guendel et al., 2001). In this paper we present evidence suggesting that the argument for not scaling up promotion of technologies may have been overstated and certainly may not be applicable to all types of technology.

It is widely accepted that resource-poor farmers (including livestock-keepers) tend to live and operate in complex and diverse environments (Chambers et al., 1989); and that there is a high degree of heterogeneity in their circumstances and farming systems (Defoer and Scoones, 2001). Some people argue that a consequence of this heterogeneity is that their main constraints vary, and also that the suitability, and hence adoption, of technologies will be limited (ibid.). The point has been made as follows:

'…micro differences are often significant enough to limit diffusion among otherwise apparently homogeneous populations … especially in varied and unstable environments' (Jiggins, 1989).

An extreme version of this view is that, in complex, diverse and risk-prone environments, 'the "recommendation domain" is, for all intents and purposes, reduced to the scale of a particular field or farm' (Okali et al., 1994).

A result of this view is that limited attention has been given to how the technical results from successful PTD may be used to benefit a much larger group of RPFs/RPHs for whom it is likely to be relevant. In this paper we argue that the use of the concept of the 'recommendation domain' is a useful tool in developing a strategy for spreading the benefits from PTD activities, and merits inclusion in literature providing guidance on dissemination of research findings and scaling up (e.g. Garforth, 1998; Guendel et al., 2001).

What is a recommendation domain and what are its uses?

The concept and tool of the 'recommendation domain' (RD) was developed in the 1970s by economists at the International Maize and Wheat Improvement Center (CIMMYT), and adopted by the Farming Systems Research and Extension community (Perrin et al., 1976; CIMMYT, 1979; Harrington and Tripp, 1984; Tripp, 1986). The use of RDs at CIMMYT began with research having a (maize or wheat) commodity focus, but early efforts to institutionalise FSR concepts within national research systems meant that they were subsequently used to characterise farming systems within administrative boundaries based on a range of crops and livestock (CIMMYT, 1979). Inevitably, the subsequent use of RDs and similar concepts and tools for characterising target populations and systems varies with the organisational and funding context (see Chapter 3 in Sutherland et al., 2001).

Differences between RDs are related to a number of parameters, both biophysical and socio-economic. They may arise due to:

- agro-ecological differences affecting the production environment (e.g. soils, climate, topography);
- differences between farmers' (or livestock-keepers') resource endowments (e.g. farm size, labour, capital);
- differences between areas (access to markets, agricultural services and infrastructure);
- cultural differences relating to decision making on production and use of crops and livestock.

Cultural factors, including religion, can, for example, influence: (a) attitudes to different types of livestock (e.g. discouraging some groups from keeping pigs or goats), and to the products derived from them (e.g. milk but not meat in vegetarian Gujarat, and cow milk but not beef among Hindus). Ownership of certain types of small stock (goats, pigs) tends to be higher among poorer groups in some countries (e.g. India).

RDs were developed and used for two inter-related purposes:

First, at the initial stages of planning research, RDs were advocated to assist with allocating scarce research resources. Collinson, quoting from a 1987 training document, notes 'At one extreme we do not have sufficient resources to carry out a research programme for every individual farmer. At the other extreme, it does not make sense to try to develop a research agenda relevant to all farmers in a country. We must compromise between these two extremes and plan research relevant to groups of farmers' (Collinson, 2000). In this context an RD has been defined as 'a group of farmers [who] have similar circumstances, resources, problems, and [hence] solutions to these problems' (Norman et al., 1995). Planning may have included planning research for a particular commodity or technical issue, or planning for the geographical mandate area of a particular research project, programme or institute. RDs identified at the planning stage are necessarily tentative, and should be regarded as such until a specific technical recommendation has been made (Tripp, 1986).

The nature and size of the RD is partly shaped in the early stages by a project's or organisation's choice of client group (e.g. poor livestock-keepers in semi-arid regions of country/province X). Domain sizes vary considerably, and 'have ranged from a few thousand farmers to several tens of thousands, or more' (Harrington and Tripp, 1984). They should not be too small, otherwise the benefits of a new technology developed for a specific domain may be less than the corresponding research costs.

Second, once an effective technology had been developed, the concept of RD[2] was used as a means of enabling relative precision in targeting those farmers or livestock-keepers for whom this technology was likely to be appropriate and adoptable. Although the use of RDs has gone out of fashion in recent years, we believe that both uses of RDs are still valid. In the remainder of this paper we focus on their second use.

Determining the size and nature of recommendation domains

Four factors that may determine the size of the recommendation domain for targeting the dissemination of a successful technology are:

1. how widespread the production constraint or opportunity[3] is;
2. the number of households involved in producing the relevant commodity (e.g. maize or scavenging poultry) or with a similar problem (e.g. soil erosion);
3. the resources (land, labour and money) available to the farmer or livestock-keeping household producing the commodity; and
4. the likely availability of the inputs needed (in the case of technologies based on locally available materials, the geographical distribution of the local material).

Information about these four factors can be obtained through a combination of primary (e.g. project surveys) and secondary (e.g. census data, other projects' reports and scientific papers) sources. However, there may be significant gaps, particularly regarding how widespread the production constraint is.

In considering the above argument we look at the potential numbers of adopters for three technologies that were developed and tested through a process of FPR/PTD, and which have been well-received by resource-poor people. The technologies are all livestock-related, and not all livestock-keepers are farmers, so hereafter we refer to resource-poor households (RPHs), rather than RPFs. We have been associated with the development of these technologies, and so our assessments could be overly optimistic. However, we have tried to avoid bias, and to use realistic assumptions.

2 THE CASE STUDIES: TECHNOLOGIES FOR 'THE POOR (WO)MAN'S COW'[4]

This section contains three examples of technologies developed with goat-keepers which have been shown, through *in situ*[5] participatory trials, to be effective in addressing priority constraints in a particular location.

They are drawn from two applied research projects with which the authors were involved, one in India and the other in Kenya, factual details of which are given in Table 1 (see p. 7).

Dryland Applied Research and Extension Project

The Dryland Applied Research and Extension Project (DAREP) covered approximately 70,000 smallholder farming families in the semi-arid areas of Embu, Tharaka-Nithi and Central Isiolo districts in Kenya. During implementation, DAREP followed a process of farming systems characterisation, diagnosis of priority constraints, trial planning, technology testing, evaluation and extension/dissemination. These were undertaken with farmers and in close collaboration with extension. The project framework had a pre-defined target group (resource-poor farmers) and target area (the semi-arid parts of three districts).

In diagnostic PRAs conducted in two districts, farmers identified animal health as the priority constraint. Farmers prioritised which animals were most important to them. Cattle ownership was concentrated among older men. Ownership of goats was more widespread, and included more young men and also women, so it was decided to focus on them. Interventions with goats that came up with useful findings stood to benefit a larger group of farmers. In goat health, three main diseases were identified by farmers and local veterinarians: contagious caprine pleuro pneumonia, gastro-intestinal parasites and mange. The first of these was already being addressed through vaccination campaigns. Interventions on worms and mange were suggested as they were endemic problems in the area and because of the existing local knowledge on their control. Some farmers had found commercial solutions to mange too expensive and had started looking for locally available alternatives.

A focused PRA, using group discussions and visits to a few local herbalists, came up with a list of about eight local concoctions that some farmers had been testing or using. This list was further screened through discussion with farmers, and a trial was designed comparing four local concoctions (the most effective of which proved to be tamarind and castor oil) which both farmers and the researcher felt reasonably comfortable using, with two recommended commercial medicines. The latter two were an organo-phosphorus acaricide, *Supa dip*, and Ivermectin, *Ivomex*: these were used as experimental controls. A mange control trial was conducted on-farm with infected herds belonging to farmers. To maintain experimental standards for comparison, the local concoctions were supplied and prepared by the researcher.

BAIF/NRI Goat Research Project

BAIF Development Research Foundation (India), a rural development NGO, and the Natural Resources Institute (UK) jointly managed a research project to identify and address feed-related constraints affecting goat production in semi-arid India. The project worked in various regions, including south Rajasthan and Dharwad District, Karnataka, primarily with poor people, who either had small/marginal farms or were landless. It aimed to develop technologies to ease or remove the constraints identified, through a process of PTD.

The BAIF/NRI project team began by doing surveys in prospective project villages, using semi-structured group interviews and mapping and diagramming. The surveys generated descriptions of the goat production and feeding systems, and identified constraints. The project then established some 'in village'[6] trials to address one of the priority problems or needs identified. The first few trials focused on supplementation of feed at critical points in the year, but subsequent trials included two in which the treatments were anthelmintics.

Tables 2–4 (see pp. 8–10) describe three of the constraints identified by the two projects, and the three technologies developed to address these constraints. In Case 1 a locally available anthelmintic material was as effective as a commercial veterinary product in reducing mortality in young goats, and in accelerating their growth. In Case 2, a concoction of two locally available materials was as effective as a commercial drug in treating sarcoptic mange in goats. In Case 3, the use of tree pods as a supplement during a period of feed scarcity significantly increased kidding rates (number of kids produced) in goats, mainly by increasing the percentage of does that conceived, but also by increasing the incidence of twins.

The cases described have a common technical focus on use of locally available natural products, two of them as an alternative option to pharmaceuticals. This focus was thought to be justified based on a diagnosis of the main socio-economic constraints surrounding the technical problems identified. Thus natural products were seen by both farmers and researchers as being locally available at minimum cash outlay compared with pharmaceuticals, which were seen to be not only expensive but also sometimes difficult to acquire in appropriate quantities. A further problem with the pharmaceuticals was quality control in a situation where official regulation of the manufacturing, packaging and administration stages left room for malpractice, resulting in substandard products which were not correctly administered to sick animals, reducing their efficacy.

While natural products may also have some similar shortcomings, the advantage is that the process of manufacture and administration is in the hands of local farmers and herbalists, who are therefore directly responsible for the results and able to use these in a quasi-experimental manner, learning as they go along. In the three cases presented, access was generally not a problem, as all of the plant/tree species tend to be found on common lands where there is open access. Potential disadvantages of the natural products are that they can also sometimes be difficult to obtain when needed; and their collection, preparation and administration requires not only knowledge and skill but also time. Nevertheless, in the disease control cases, livestock-keepers saw the commercial products as less attractive options than the natural ones: the cash outlay required for the former was seen as more of a constraint than the labour requirements of the latter, which are quite small. Labour costs are potentially more significant for the high-quality feed supplement (tree pods). In this case, it may be important that the pods can be collected at a time when there is a trough in the labour calendar.

Points 1 to 4 in Tables 2 to 4 correspond with the four factors mentioned in the previous section, and illustrate how these factors can be taken into account in estimating RDs. Points 5 and 6 in the tables go further and describe the potential relevance of the technology, or a slightly modified version of it, to other constraints or commodities or outside of the original country. Two of the tables also include information about commercial products that were available to address the constraint, and which were tested along with the technology based on locally available materials. The tables distinguish between the availability and accessibility of inputs associated with the technologies. Availability refers to the physical presence of the materials, whereas accessibility refers to whether or not RPHs have entitlements (effective claims) to the materials.

Estimates of the recommendation domains

Preliminary estimates of the RDs for the three technologies are given in Tables 5–7. The assumptions are based on the information given in Tables 2–4 respectively.

Table 5 contains specific assumptions, based on the information in Table 2, and on some guesses where information is lacking. Based on different sets of assumptions for Dharwad, Karnataka and India, it shows the sizes of the recommendation domains for each. Using the Dharwad example, the size of the RDs has been estimated as follows:

Dharwad RD = 14,400 x 40% x 25% x 90%
= 1296

The assumptions used are more conservative as the geographical unit increases in size, because the degree of uncertainty is also increasing and there is a growing likelihood that conditions (e.g. regarding the prevalence of the constraint, and the labour situation) may differ from those in the original project district.

Table 6 contains comparable information for the mange control technology. The specific assumptions in it are based on the information in Table 3, and some guesses where information is lacking.

Finally, Table 7 contains information from which the RD for the *P. juliflora* pods technology has been estimated.

These RD estimates are conservative in two respects. First, in Cases 1 and 3 no attempt has been made to include RPHs outside of India in the RDs, but the co-existence of goats and *P. juliflora*, and goats and *M. pruriens* in several other countries, suggests that the global RDs for both of these technologies could be considerably larger than the Indian one. The same applies to Case 2, in that the co-existence of goats, castor oil plants and tamarind trees is found in the semi-arid and sub-humid parts of many other African countries, and also in South Asia. Second, no assumptions have been made about the applicability of the technologies to other types of ruminants, although there is evidence that all of them may have a broader relevance. It should be borne in mind, however, that, if the technologies are applicable to other types of ruminants, the beneficiaries could be different and hence the RD could be different.

3 DISCUSSION AND CONCLUSIONS

Some of the information on which the RD estimates in Tables 5–7 are based is uncertain. For example, there is a lack of information as to how widespread the constraints are; and some constraints (e.g. low conception rates in the dry season) are less visible than others (e.g. mange), making it difficult to detect their presence. In addition, regarding Case 3, the opportunity cost of labour could vary significantly from one part of India to another. Another uncertainty is to what extent goat-keepers outside of the initial project locations might already be using the technologies developed, or variants of them, given that the technologies draw on indigenous knowledge. Nevertheless, they do contain strong *prima facie* evidence that the RDs for these three technologies, all of which are based on locally available materials, could involve tens of thousands of resource-poor livestock-keepers, if not a hundred thousand or more, in each case.

There is also some *empirical* evidence that RDs for RPFs can be large. For example, Maurya (1989) gave examples of crop varieties that had spread rapidly and widely in India from farmer to farmer, without government support. One of these, the paddy variety *Mahsuri*, was eventually used in six different states and became the third most popular variety in the country. Clearly, it has a very large RD, with millions of adopters. Even if only 10% of the adopters were RPFs, one would still be talking about 100,000 or more.

For commercial veterinary drugs the major barriers to their adoption by resource-poor households appear to be cost, packaging size and perhaps in some cases availability. Private sector agencies have been able to ensure that the drugs are physically available in major rural centres. By contrast, for PTD-generated technologies, particularly ones that are knowledge-based, the major barrier is access to information about them, so getting that information to the RPHs is the challenge that needs to be addressed.

Reasons for limited promotion of technologies

As we noted earlier, there has been a general failure in PTD projects to combine breadth with depth. Greater breadth could relate to technological change (the subject of this paper) or empowerment, and the latter is much more difficult to achieve than the former (Farrington, 1998). There may be several reasons for the limited coverage achieved in relation to technological change (see also Guendel et al., 2001).

First, agencies primarily concerned with empowerment may not attach high priority to promoting technologies outside their operational area. Whilst not underestimating the importance of empowering research approaches, we would argue that wider impact can be achieved more easily through promoting technological change than by out-scaling the PTD process. The latter is difficult, because PTD is about partnership between researchers and producers, and the ratio of researchers to producers is very low.

Second, in the case of a small or medium-sized NGO or a state/province agricultural university, the agencies concerned could have a small operational area, and hence not be well equipped to promote the technologies themselves.

Third, development agencies with smaller operational areas may only be concerned with adoption of technologies by resource-poor people in those areas, such as a few dozen or hundred villages in a particular district. Their mindset may be somewhat parochial, and they may not be used to thinking how they can achieve impact over a much larger area and RD.

Nevertheless, agencies involved in PTD, if they are genuinely interested in poverty reduction, should be asking themselves how they are going to maximise the benefits from the technologies they have developed with RPHs, if necessary by encouraging intermediary organisations to promote them to relevant RPHs. A serious attempt should be made to identify which RPHs would find the technologies useful, and where they are located. The recommendation domain tool is ideal for this purpose.

Practicalities of using recommendation domains

It appears that the recommendation domain tool has not been widely used by agencies involved in FPR/ PTD. There are several possible reasons for this.

First, some agencies, particularly NGOs, may not be familiar with the literature on RDs.

Second, although estimating RDs is a conceptually simple process, the necessary data are often lacking or difficult to obtain.

Third, the recommendation domains can be so large that they can extend well beyond the operational area of the lead agency that was involved in developing the technology, particularly when that agency is only covering a district or a small area within a district. RDs may include households located in a large area of a country, or of more than one country. Thus, effective promotion of a technology throughout the RD may require the involvement of at least two, and perhaps several, agencies. In the case studies, the lead agencies were large ones, with the potential to promote technologies over a huge area. BAIF works in six Indian states and has distributed dissemination materials for technologies 1 and 3 in all of those states, while KARI has a national mandate and presence.

In this context, KARI has recently taken on direct responsibility for some technology dissemination activities (including seed of some crops). At the same time, the importance of improving the existing linkages of KARI with extension services and NGOs is recognised. What is not yet in place in Kenya and many other countries (developed and developing) is a coherent, clearly articulated and sustainable strategy to promote promising research outputs to the appropriate agencies in order to improve the returns from research investment. Experience suggests that to rely only on demand for information and advice is not enough, particularly when the agencies involved in knowledge transfer are not well resourced and are ill-equipped to convert research information into tangible benefits for marginalised rural producers. Donors should consider taking a more pro-active approach to promoting promising technologies, including support for ‘product champions’ who have the expertise and motivation to promote the technology vigorously.

Fourth, projects usually fund research but not widespread dissemination. Hence the researchers are not challenged to think further than successful research with a local group of producers.

The definition of the recommendation domain may affect the choice of intermediary organisations. For example, if the PTD project or organisation concludes that one or more of its recommendations are relevant outside of the districts where it has an operational presence or mandate, it could identify relevant organisations working in other locations within the recommendation domain to promote the recommendation in that area; and then develop a strategy for reaching them effectively.

In the case of relatively small PTD projects, with limited resources, the presence of potential intermediary organisation(s), with the capacity to disseminate findings on a larger scale, could be a criterion for selecting the area in which the project is going to work. (This would be the first use of the RD concept.) If communication is established with intermediary organisations early on in the project, and then sustained over time, the likelihood of their taking an interest in the project’s findings will be greatly enhanced. In the case of larger projects (or programmes) a consortium of collaborating organisations may be formed in the early stages. This was done, for example, by a Kenyan project on the validation of ethnoveterinary knowledge, which brought together NGOs, national research institutes, veterinary practitioners and local healers (Wanyama, 1999).

The use of RDs in priority-setting

As mentioned at the start, the first use of RD is as a research-planning tool, helping decision making about targeting research activities and prioritising the use of scarce research resources. This is appropriate for agencies thinking about embarking on new PTD activities, and which need to prioritise in terms of technical, geographical and socio-economic focus. This process can begin at the needs assessment stage, before technologies have been identified, since RDs are more likely to be large when: (a) the relevant commodity (or commodities) is produced by a large number of RPHs; and (b) the constraint or opportunity is widely experienced. The examples given above also suggest that low or zero cash requirements may be another condition to consider when screening which technologies to field test with RPHs. Some technologies will be more sensitive than others to variations in conditions – for example, the suitability of a particular type of plough may be strongly affected by soil conditions and topography, so if these were highly variable the RD would be small or patchy.

A more common situation is that of agencies (NGOs, public research institutes, universities) which have undertaken some PTD successfully, but have done relatively little in terms of promoting the technical findings beyond their operational research areas. Agencies that have done successful FPR/PTD should give careful consideration to prioritising the promotion of technologies that appear to have large RDs and that include substantial numbers of RPHs.

In addition to being used by researching agencies, RDs can also be used in priority-setting by disseminating agencies. Where a large organisation or project has developed several effective technologies, and where resources for dissemination are scarce, priority can be given to those technologies with the largest RDs. Alternatively, where an agency with a mandate for dissemination (e.g. public extension services) has a large number of technologies to choose from, and the mechanism for effective articulation of demand is weak, RD analysis along the lines demonstrated in this paper can be used in determining priorities.

Conclusions

These three cases strongly suggest that the RDs for certain technologies developed for, and with, RPHs can be large. This is important, because it strengthens the justification for adopting a participatory approach to technology development, despite the fact that it is inherently resource-intensive. However, in order to maximise the cost-effectiveness of PTD it is necessary to identify who the potential adopters are, and to design and implement a dissemination strategy for reaching them. The estimation of RDs is a valuable tool for doing this, both during the planning of research and in the promotion and dissemination of technical results.

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ENDNOTES

1 Favourable internal conditions for not changing more conventional 'transfer of technology' approaches included a strong cadre of national scientists who had a track record in developing technologies and getting these successfully promoted so that they had clearly visible impact. Favourable external conditions included a relatively large and homogenous farming population with similar conditions (such as the irrigated rice-based systems of South Asia) and a well funded and supportive national extension programme (publicly funded extension promoting the technologies) and policy framework (agricultural credit and subsidies for the main inputs of seed and fertiliser). The converse would be a highly heterogenous farming population with diverse conditions, weak public extension services and lack of effective public sector support for agricultural credit, input supply and marketing.

2 Some people would argue that, strictly speaking, the term 'recommendation domain' should only be used in this context, on the grounds that you cannot estimate one until you have a technology to recommend; and that the term 'research domain' is more appropriate in relation to the first purpose described above. We have used the term 'recommendation domain' in a loose sense to cover both of these situations.

3 Opportunities often arise where product markets (e.g. for milk) are better developed. Good transport systems can link livestock producers to urban areas, where the demand for milk and meat is often relatively high, and where prices are often higher. Good market prices for products may justify the adoption of input technologies (e.g. certain fodders) that would not have been financially attractive otherwise.

4 Mahatma Gandhi described the goat as 'the poor man's cow'.

5 The term *in situ* is used here in preference to 'on farm', because some of the participants were landless.

6 Some of the participating goat-keepers were landless, so the usual term, 'on-farm', is not appropriate

Table 1 The case study projects

Project title	**Dryland Applied Research and Extension Project**	**Easing Seasonal Scarcity for Goats, through a Process of Participatory Research**
Locations	Mbeere, Tharaka-Nithi and Central Isiolo districts	Five districts, including Bhilwara (Rajasthan) and Dharwad (Karnataka)
Country	Kenya	India
Principal agencies involved	1. Kenya Agricultural Research Institute, Regional Research Centre – Embu 2. Department of Extension (Veterinary Officer) 3. Natural Resources Institute	1. BAIF Development Research Foundation 2. Natural Resources Institute
Donor	DFID's Natural Resources Systems Programme	DFID's Livestock Production Programme
Duration	1993–7	1997–2002

Table 2 Description of Case 1 and information required to estimate RD

Production constraint	High kid mortality in the rainy season due to gastro-intestinal parasites in does and their kids	
Main sources of information	Conroy and Thakur (2002); Conroy et al. (2002); Thakur et al. (2002)	
Recommended technology	Drenching with trichomes of *Mucuna pruriens* pods and jaggery (sugar)	Drenching with *Fenbendazole*
Initial location	Dharwad District, Karnataka, India	
1. How widespread is constraint in original project location and country?	Project surveys only covered six villages in two locations about 70 km apart. There is a need for further analysis, based on surveys, talking to key informants, analysis of secondary information, etc. (also see point 6 below). The level of annual rainfall may have a strong influence on the importance of the constraint. Variations in the timing of the principal kidding season may also determine whether the constraint exists in particular areas or groups of livestock-keepers, i.e. where few kids are born during the rainy season there may not be a mortality problem.	
2. How widespread is the commodity?	A survey in 1997 found that there were 64,639 goats in Dharwad District; and there were 3,838,000 in Karnataka in 1990 (livestock census). A project survey suggests that average herd size in the project villages is 4–5. There are about 120 million goats in India, which are kept by about 12–30 million families.	
3. Farmer resources required for adoption	This technology does not require private land or cash. The only resource involved in utilising it is the labour required to harvest and process the pods. This is very little. The pods occur in bunches and only four or five bunches are needed to meet the requirements of goat-keepers with small herds. In Karnataka, pods are harvested in late February and in March.	This technology requires cash. The price of purchasing enough of the drug to treat one animal would be Rs. 6 (Rs.3 per dose) for a goat weighing 20 kg. The market for drugs to control the helminths of sheep and goats is relatively small, which suggests that price is a serious deterrent.
4. (a) Availability and (b) accessibility of raw materials in project country	(a) *Mucuna pruriens* may only be found in particular agro-ecological zones (e.g. within a certain range of annual rainfall, perhaps 600–1500 mm p.a.). Data on its distribution are lacking, but it is known to be present in parts of Orissa and Rajasthan, as well as Karnataka. (b) In India *M. pruriens* is commonly found growing uncultivated by roadsides, in forest areas and on private land, making it accessible to everyone in these areas. It would not be accessible outside of areas where it grows, unless the material could be *purchased* at low cost by goat-keepers in such areas.	(a) *Fenbendazole* is produced by numerous companies and is widely distributed in major rural centres in India. It tends not to be available in relatively remote areas. (b) At these centres it is accessible to anyone who can afford to purchase it commercially (see below).
5. Any evidence of its adaptability?	The technology is used by buffalo-keepers, which gave researchers the idea of using it on goats. It could, therefore, be effective in deworming large ruminants, with appropriate modifications to dose rates.	*Fenbendazole* has a broad spectrum of activity in cattle, buffalo and sheep as well as goats (www.vetcareindia.com).
6. Any evidence of relevance outside district, state or country of origin? (a) constraint (b) technology	(a) Nematode infestations of does and their kids are 'one of the main causes of death among kids' in the tropics (Peacock, 1996). (b) *M. pruriens* is also found in Mexico, the Caribbean and Nigeria (Kiff et al., 1996).	(a) Nematode infestations of does and their kids are 'one of the main causes of death among kids' in the tropics (Peacock,1996). (b) Fenbendazole is used in many tropical countries.

Table 3 Description of Case 2 and information required to estimate RD

Production constraint	Sarcoptic mange in goats	
Main sources of information	Sutherland and Kang'ara (2000)	
Recommended technology	Tamarind fruit paste mixed with oily paste of crushed roasted castor oil seed in equal quantities – applied weekly for four weeks.	Ivermectin, an injectable drug that is commercially available. Injection is repeated seven days after the initial dose: each dose is 1 ml.
Initial location	Tharaka-Nithi and Mbeere Districts, Kenya	
1. How widespread is constraint in original project location and country?	Project survey found that mange is the second most important cause of mortality in goats in the districts. The survey covered four sub-locations in Tharaka District and four in Mbeere District. Mange occurs in most arid and semi-arid lands (ASAL) of Kenya, including Kajiado, Kitui, Makueni, Machakos, Mwingi and Narok.	
2. How widespread is the commodity?	At least 75% of the 50,000 households in the project districts, and in other mange-endemic areas, keep goats. There are c. 344,195 goats in the project districts, so average herd size is about nine. There are about 10 million goats in Kenya. About 20% of Kenya's human population of 31 million live in ASAL areas, and about 80% of meat goats are found in ASAL areas.	
3. Farmer resources required for adoption	This technology does not require land or cash, unless the fruit is purchased. The only resource required to utilise it is the labour required to harvest and process the raw materials. Nevertheless, it would be important to check whether the harvesting time coincides with a seasonal labour peak.	Ivermectin is 'quite expensive' (Peacock, 1996). In the project area, a 50 ml bottle of Ivomec cost about Ksh 5000 (equivalent to US$62), and was enough to treat 25 mature goats. A farmer would have had to sell 4–6 healthy goats to save 25 sick goats, which was not seen as attractive, and it was difficult to sell a goat from a sick flock even if it was healthy.
4. (a) Availability and (b) accessibility of raw materials in project country	(a) *Tamarindus indica* is quite widespread in the villages where the trials were conducted, and in much of semi-arid Kenya. It was less common in a second area, Gategi, leading livestock-keepers to plant it there. The fruit is also sold in local markets, where it is cheap in season. Castor (*Ricinus comunis*) is also widespread. (b) Both ingredients are reasonably accessible (even to resource-poor people), particularly castor, which has become a weed in some places.	(a) Ivermectin is available in towns in the project districts, under the trade name Ivomec®. (b) At these centres Ivomec is accessible to anyone who is prepared to purchase it commercially (see below).
5. Any evidence of technology's adaptability?	Sheep and calves were also infected with mange, and were treated effectively by the project.	The technology is effective in treating other ruminants.
6. Any evidence of technology's relevance outside district or country of origin? (a) constraint (b) technology	(a) Sarcoptic mange is by far the most important mange of goats in the tropics, and in some systems it can be the most important cause of death (Peacock, 1996). Mange is endemic in 10% of Kenya's ASAL area . (b) *Tamarindus indica* is found in many semi-arid regions of sub-Saharan Africa and India. Castor grows in a very wide range of environments in the tropics (Peacock, 1996).	(a) Sarcoptic mange is by far the most important mange of goats in the tropics, and in some systems it can be the most important cause of death (Peacock, 1996). Mange is endemic in 10% of Kenya's ASAL area . (b) Ivermectin is used in many tropical countries.

Table 4 Description of Case 3 and information required to estimate RD

Production constraint	Low conception rates in goats in the dry season (February–June inclusive)
Main source of information	Conroy et al. (2002)
Recommended technology	Supplementation with 250 g/day of *Prosopis juliflora* pods for 10 weeks around the desired time of breeding
Initial location	Bhilwara District, Rajasthan, India
1. How widespread is constraint in original project location and country?	*Bhilwara District* is semi-arid, with a mean annual rainfall of 700 mm. Project survey covering six villages in the district identified feed scarcity as a constraint in all of them. In five villages scarcity in dry season was specified, and in some June was identified as the worst month. The latter part of the dry season is the preferred breeding season, as kids are then born after the rainy season, when there is less disease but plenty of forage. Trials in four villages all resulted in higher conception rates. *Other districts*: In similar surveys in villages in three other semi-arid districts (one each in Rajasthan, Gujarat and Karnataka), goat-keepers also identified this as a serious constraint. In another district (in Madhya Pradesh) it was not seen as a constraint. *General observation*: The surveys suggest that feed scarcity in the dry season is a constraint where access to browsable material on private lands and common lands near the village is limited, i.e. there is a lack of forests and/or shrubs to which goat-keepers have usufructuary rights. It may also decrease in importance as mean annual rainfall increases. Seasonal migration may overcome the problem, but this is only practised by a minority of agropastoralists, mainly those with large flocks/herds of small ruminants. It is not known how widespread the preference for breeding in the dry season is. More villages need to be surveyed and secondary data analysed to answer this question.
2. How widespread is the commodity?	In 1997, there were about 16.9 million goats in Rajasthan and 700,000 in Bhilwara (livestock census). Average herd size, excluding kids, is about 10 (Sagar and Ahuja, 1993), so the number of households owning goats may be about 1.7 million and 70,000 for the state and district respectively. There are 120 million goats in India as a whole (livestock census), kept by about 12–30 million households (author's guesstimate). It is not known what proportion live in areas where *P. juliflora* is found, but goat ownership does tend to be higher in dryland regions.
3. Farmer resources required for adoption	This technology does not require land or cash. The only resource required to utilise it is the labour needed to harvest and process the pods. Nevertheless, it would be important to check whether the harvesting time coincides with a seasonal labour peak. If it does, this could deter people from using the technology. In Bhilwara District, harvesting occurs when demand for labour is low.
4. (a) Availability and (b) accessibility of raw materials in project country	(a) *Prosopis juliflora* is the most dominant and widespread tree species in India's arid and semi-arid regions, supplying 75% of fuelwood needs in these regions (Tewari et al., 2000). It is also widespread in sub-humid regions. In four states of India (Andhra Pradesh, Gujarat, Maharashtra and Rajasthan) at least 20% of the land area is arid/semi-arid (ibid.). (b) *P. juliflora* is commonly found growing uncultivated by roadsides, and on common lands, making it accessible to a large proportion of households in arid/semi-arid India.
5. Any evidence of technology's adaptability?	In Karnataka, PJ pods have been used as a supplement for does around the time of kidding. This improved the health of pregnant does and increased their milk production, hence their kids were healthier and grew faster. In this case, because the tree pods are being stored for use in the rainy season, pest damage appears to be a greater threat, and the technology has been adapted through the introduction of fumigation.
6. Any evidence of technology's relevance outside district or country of origin? (a) constraint (b) technology	(a) Its original use and point 5 above suggest that it may be effective in addressing a number of constraints on goat productivity. (b) *P. juliflora* is a native of Venezuela and Colombia. It is an exotic weed in parts of Sudan, Eritrea, Iraq, Pakistan, Australia, S. Africa and the Caribbean (Pasiecznik, 2001). It is also found in NE Brazil, where its pods are used as an ingredient in commercial cattle feed.

Table 5 Size of RD for *Mucuna pruriens* trichomes as a goat dewormer

Assumptions	**Dharwad**	**Karnataka**	**India**
No. of goat-owning households	14,400	852,900	20,000,000
% whose goats are experiencing constraint	40	20	10
% having access to *M. pruriens* pods	25	15	10
% having labour to collect them	90	90	75
Result			
Size of domain (no. of households)	1,296	23,028	150,000

Table 6 Size of RD for treating mange-infested goats with castor and tamarind paste

Assumptions	**Tharaka, Mbeere and Central Isiolo**	**Kenya**	**East Africa**
No. of goat-owning households	75% of 50,000	40% of 6 million	40% of 15 million
% whose goats are at risk* of experiencing constraint	80	50	50
% having access to Castor and *Tamarindus indica*	50	30	30
% having labour to collect and process them	60	60	60
Result			
Size of domain (no. of households)	9,000	216,000	540,000

* While less than 10% of herds may be badly affected at any one time, the risk of getting infected over a period of three to five years is high.

Table 7 Size of RD for supplement of *Prosopis juliflora* pods to improve the productivity of does

Assumptions	**Bhilwara**	**Rajasthan**	**India**
No. of goat-owning households	70,000	1,700,000	20,000,000
% whose goats are experiencing constraint	75	25	15
% having access to *P. juliflora* pods	25	10	15
% having labour to collect them	75	50	25
Result			
Size of domain (no. of households)	9,844	21,250	112,500

* While less than 10% of herds may be badly affected at any one time, the risk of getting infected over a period of three to five years is high.

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