Services for Rural Development

Sector Project “Knowledge Systems in Rural Areas”

Reader: Agricultural Research Systems

CONTENT

1. Introduction

Research can contribute substantially to advancing agriculture under the condition of capacity of research institutions that respond to the needs of the farming community. Agricultural research has always been regarded as a public task because of the public good nature of many agricultural technologies and of the knowledge generated by research. Since the green revolution era, many countries have made considerable investments in expanding their public research facilities, mostly with international assistance. Their intention was to create enough capacity to carry out a public national research programme. However, this policy has led to a number of structural problems, in particular to a high degree of centralization of agricultural research systems and substantial follow-up costs which have burdened increasingly tight public budgets. The traditional model of public sector-based research also implies hierarchical decision and funding mechanisms, which have prevented farmers from effectively exercising control over research programmes. As a result, there is a clear need to rationalize agricultural research policy and reform the institutional set-up of research. This article provides an overview of the recent topics in strengthening national agricultural research and promoting agricultural innovation.

2. Agricultural Research Systems

2.1. Systems Perspective

The concept of systems follows the ideas of systems thinking, using a "soft systems" methodology. Soft systems methods are analytical tools that help the user to understand complex, interrelated and self-regulating social structures that are not adequately described in terms of linear cause-effect relationships. Below you will find a brief summary of the underlying definitions and terminology:

- A 'system' is understood here as a social system, leaving (agro-) ecological systems, technical systems etc. aside.
- Systems consist of elements, functional relations between these elements depending on each other, a boundary separating system and system environment and a staggered hierarchy of (sub)-systems. Systems represent a dynamic but stable social structure.

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● People belonging to the system are organised around a common agenda or common interests (at least partially). The system thus serves a purpose (e.g. producing a particular commodity or improving the production of that commodity). Each participant has a "stake" in the system.

The analyst of systems has to select the social system to be analysed and determine the boundaries. A series of analytical steps defining and analysing social systems needs to be taken, as for instance the user should:

● determine the type of the service system (i.e. its objectives, the common agenda of stakeholders). The systems approach can be applied to a variety of issues: e.g. agricultural services, innovation or traditional knowledge exchange

● define system boundaries, deciding what belongs to it and what makes up its environment

● verify hypotheses on the system type and its boundaries by cross-checking with the views of people involved in the system.

Applied to agriculture the systems-approach allows identifying problems in the interplay of market and non-market organisations or in the institutional relations between government and farmers. This applies for both commercial agriculture and public development policies:

→ In a commercial agricultural context, economic development leads to an increasing specialization of services that need to be coordinated. Mostly, the coordination (governance) mechanism is the market for agricultural inputs and services. However, for these markets to function effectively, governments are often obliged to intervene in order to regulate quality and secure the legal framework.

→ Services provided for the common good often require distinct functions (political programming and supervision, public funding, service delivery) which are performed by different institutions, such as the central government, subordinate government departments, public service organisations, development committees etc.

2.2. Definition of National Agricultural Research Systems (NARS)

A **National Agricultural Research System** comprises all a country's entities responsible for organising, coordinating, or executing research that contributes explicitly to the development of its agriculture and the maintenance of its natural resource base (ISNAR, 1990). The tasks of NARS include creation of research capacity and set priorities, improving of the governance of research, facilitating innovation, and regulating intellectual property rights (IPR).

Agricultural research includes research on crops, livestock, forestry, fisheries and the use of agricultural inputs, natural resources, and socioeconomic aspects of primary agricultural production. Also included is research concerning the storage and processing of agricultural products, commonly referred to as post-harvest or food-processing research. Such research usually deals with both on-farm and off-farm issues.

2.3. Governance and Management of Agricultural Research Systems

Many public sector agricultural research organizations are faced with fundamental questions about their relevance and productivity in a rapidly changing external environment. In such situations the focus on strengthening management will not achieve the necessary strategic reorientation. Publicly funded agricultural research is effectively governed if it meets the criteria of performance and accountability. Performance relates to concepts of value for money, efficiency, productivity, outputs and outcomes. Accountability refers to the public role of agricultural research and the relevance of activities to the different internal and external clients and stakeholders. What is required is a more fundamental revision of research governance, defined as the way organisations are steered and directed. Innovative governance mechanisms play an important role in developing agricultural research systems. While in many countries agricultural research continues to be organised according to traditional public sector hierarchy models, alternative modes of governance are increasingly being explored. Main headings of governance in this area refer to:

● Legitimacy: the legal basis for an organisation to pursue its agenda and the acceptance by the organisation's constituency of the organisation's role.

● Steering and supervision: with regard to organisations, departments, units, and key individuals.

● Strategic direction: a key function of governance is to determine the course of the organisation

● Structuring of decision-making: centralisation and decentralisation issues.

● Alliances and linkages: deciding on which external relationships to develop and maintain.

Governance issues need to be analysed at different levels. The most important ones are the level of the research organisation, the sectoral or regional level, and the national and international levels.

● The concept of **"corporate governance"** originates in the private sector, but is increasingly used in the public sector, too. It includes issues such as supervision and steering by a Board, decision-making on strategic direction, executive leadership, and the use of incentives to enhance performance.

● At the **regional** or **sectoral level** the emphasis of governance is on research and development networks of organisations that focus on specific innovations. Effective networks usually include a variety of partners: research organisations, extension organisations, producer groups and NGOs. Often these networks lack a formal governance structure and depend on the voluntary participation of organisations.

● At the **national level**, governance mechanisms can take a variety of forms. Steering of the National Agricultural Research System (NARS) may take place via the Ministry of Agriculture or through a (semi) autonomous Agricultural Research Council, which could coordinate the research agenda of a variety of institutes.

● At the **international/regional level**, supra-national institutes and regional networks or associations play an important role in agricultural research. International/regional research institutions can focus on one issue or commodity or they may be concerned more broadly with organisational, management, or policy issues. The nature of joint activities may vary from exchanging information on a voluntary basis to joint research in supranational institutes.

Efforts to improve the governance of an organisation need to deal with both its internal and external environment. A starting point is provided by a review of the organisation's long-term strategic objectives. The organisation's mandate, internal decision-making structures, and its supervision by an appropriate governing body, need to reflect the requirements imposed by the long-term strategic objectives. Particular attention needs to be given to deciding on the organisational boundaries: i.e. what the organisation will do itself and what it will leave to others. Externally, governance needs to address questions of stakeholder accountability, inter-organisational coordination, networking and alliances with a variety of organisations including parent ministries, farmers' organisations, private organisations and others.

In an increasingly globalized world, collaboration and networking among research organisations and across borders is a necessity, especially for low-income countries with limited access to scientific knowledge. The capacity of NARS can be enhanced substantially by collaborations - and networking is a form of research governance that combines flexibility of research operations on the one hand with the commitment to a lasting partnership on the other. Another objective of networks is the increased resource efficiency. There are different types of networks according to the objectives and the intensity of co-operation. Specific forms of networking are regional associations of agricultural research such as ASARECA in Eastern Africa or CORAF in West Africa. Providing institutional stability and realizing the desired synergies is a matter of effectively setting up and managing research networks, and hence an institution building task. A number of principles for the development of research networks need to be observed, such as checking on the conditions for success, setting objectives accordingly, and designing efficient rules for sharing resources.

2.4. Intellectual Property Rights (IPR)

Intellectual property is a broad term for the various rights that the law confers for the protection of economic investment in creative effort. The most important mechanisms for legally protecting agricultural innovations are plant variety rights (PVR) and patents (extended to cover plants, animals and micro organisms). Other forms of protection can be provided through trademarks, trade secrets and copyright. Alternatives to these include material transfer agreements (MTAs) that are of a private contractual nature. If no form of protection is adopted, then research results are generally placed in the public domain, mostly in the form of publications, making results available to all without restrictions on their use. Plant variety rights (PVR) have been highly successful in their own sphere. However, the use of patent law is increasingly viewed as better suited for the protection of methods for producing transgenic plants and the resulting products. PVR are highly specific to

the variety as de-scribed in the documentation granting the rights. The freedom to undertake research involving protected technologies is safeguarded under both patent and PVR law, whereas the commercialization of the resulting products of research depends on whether they infringe patent claims or are "essentially derived" under PVR legislation. A growing number of developing countries are revising or setting up their systems to protect intellectual property rights (IPR). As members of the World Trade Organization (WTO), they are bound to introduce international standards for the protection of IPRs. The extent to which changes in IPR legislation in developing countries will in fact lead to accelerated technology transfers and to greater agricultural innovation remains to be seen.

Agricultural scientists and policy makers in developing countries are facing complex questions and decisions about the protection of intellectual property rights (IPR) in agricultural research. Agricultural research has benefited from a long history of public-sector investment and a free exchange of technologies and genetic resources. Recently, an increased emphasis on market mechanisms has forced publicly-funded organizations to respond to broader economic and market opportunities, and, as a result, to protect their germplasm and research results by invoking intellectual property rights. Private companies routinely seek patent protection for their inventions, and this practice is also becoming prevalent at universities and advanced research institutes in industrialized countries. Access to new agricultural technology increasingly depends on the capacity of a receiving country or research institute to enforce the protection of intellectual property. A growing number of agricultural research organisations in developing countries are setting up special units to manage intellectual property and the transfer of technologies. For example, an Intellectual Property Secretariat was established at EMBRAPA (Brazil's agricultural research corporation) in 1998, in order to implement the organisation's recently formulated policy and guidelines for managing IPR. This Secretariat serves as a coordinating mechanism for the management of EMBRAPA's proprietary assets (e.g., genes, varieties, software, CDs) and for the licensing of third-party proprietary assets. In addition, the Secretariat serves as the organisation's policy making body, keeping IPR policy in line with rapid global developments.

3. Agricultural Innovation

3.1. Concept of Agricultural Innovation

According to the linear model of innovation, agricultural innovation is driven by research being the origin of new technology. Agricultural research is believed to be the only active force pushing the innovation process by providing technology, while farmers are rather passive receivers, 'adopters' of a preconceived solution. Thus the innovation process is seen as linear and unidirectional, leading from research to farm-level change. The linear model is the foundation for the transfer-of-technology (tot) concept in research and extension. It has met with considerable criticism in the last two decades because it does not take account of the economic, social and institutional conditions under which innovations actually take place. Observation shows that there are several sources of technology, that research itself is being driven by economic and political forces, and that every innovation process is bound to specific economic and institutional circumstances.

Recent theory emphasizes the social character of innovation. The innovation process is recognised as a continuous learning process that evolves in cycles, in feedback loops between farmers (technology users) and the providers of technological services. This process can start at any point, be it a research idea, a practical farming problem, a market opportunity or a development project supporting local initiatives.

Another important insight is that technology is deeply embedded in rural social systems: Adoption depends on the economic and social conditions under which technology users operate. The technical change depends on production location, markets and resources, but also on the availability of complementary products and services and on cultural values, and the interests of the various stakeholders. Technologies are selected and adapted (and even negotiated) to serve these interests. They need to fit in before they can be applied. Hence, the **institutional set-up** of a specific commodity sector or the social relations at a particular location are decisive aspects in explaining change. Understanding innovation includes analysing the potential, the incentives and the interaction of the multiple social actors involved in technical change. As the conditions are quite specific to different groups of people, this study has to be done separately in each case.

In fact, today the systems view on innovation is widely accepted as an adequate approach to the diagnosis of constraints and the design of development activities supporting agricultural innovation. The most prominent concepts to be found in the literature include:

● **Agricultural Knowledge and Information Systems (AKIS)**. (Similar terms are AKS, the Agricultural Knowledge System and ARKIS, the Agricultural and Rural Knowledge and Information System.) The AKIS concept has been introduced by Niels RÖLING. In his definition "an AKIS is a set of agricultural organizations and/or persons, and the links and interactions between them, engaged in processes as the generation, transformation, transmission, storage, retrieval, integration, diffusion and utilization of knowledge and information, with the purpose of working synergically to support decision making, problem solving and innovation in a given country's agriculture or a domain thereof". (RÖLING, N., 1990: "The Agricultural Research-Technology Interface: A Knowledge Systems Perspective". in: "Making the Link: Agricultural Research and Technology Transfer in Developing Countries", ed. by D. Kaimowitz, 1990). The definition of the Worldbank is more restrictive: "An Agricultural Knowledge and Information System (AKIS) is a system of people and institutions that generated transfers and utilizes agricultural knowledge and information. The system is characterized by its key subsystems: agricultural education, agricultural research and agricultural extension."

● **Agricultural Technology Systems (ATS)**. (A similar term is ATMS, the Agricultural Technology Management System.) A generic ATS or ATMS is composed of interrelated components including a "technology sector" (made up of a technology-generating system, a technology-using system and a technology-transfer system) embedded in a "politico-bureaucratic structure", the "policy environment", the "structural conditions" such as world markets, and the "external environment" (donors and international technology-generating and -transferring systems). (ELLIOTT, H., 1990: "Applying ATMS Approaches in widely different Systems: Lessons from ISNAR's experience" in: "Methods for Diagnosing Research System Constraints and Assessing the Impact of Agricultural Research", ISNAR, The Hague).

3.2. Identification of Innovation Possibilities

The screening and identification of the potential for innovation is the first stage in a sequence of four to analyse agricultural innovation from a systems perspective. It refers to the various economic conditions (of location, markets and resources and the availability of complementary products and services) which are a precondition for innovation to actually take place.

Conditions that need to be in place to generate a demand for technology include:

● adequate natural conditions of the location, i.e. the natural potential for intensifying agricultural production, and sufficient availability of water. The innovation potential is given by a comparison with average and maximum yield levels in other regions.

● adequate economic and institutional conditions of the location, especially access to credit, transport and markets and availability of complementary production inputs and services.

● incentives to actually intensify production and produce more: This presupposes that markets are available (e.g. a situation of increasing demand for agricultural products or when there is a market potential for new products). Often, the incentive to innovate is a consequence of the need to reduce costs in commercial agriculture in order to stay competitive

or:

● a need to compensate increasing land scarcity and/or a decline in resource productivity as a result of rural population increase with few income alternatives. In such a situation, innovation is necessary to make up for diminishing incomes.

Even if the general (macro-level) conditions are in place, not all individual farmers (micro level) will actually have an incentive to innovate. There are a number of conditions at the farm level, which need to be fulfilled as well:

● the expected benefits from adopting an innovation exceed the perceived risk

● the individual farmer has enough own resources (land, labour, capital and knowledge) to be able to apply a new technology.

To **determine the demand for technology** the following sequence of steps is warranted:

→ select a location, and a commodity or group of farms

→ check the basic conditions of markets and of the location that are in favour of or against innovation. This delivers a potential demand of the farming community at large. This step also involves to identify the specific locations (village clusters) within a region which have an innovation potential.

→ check farm level conditions (second set of criteria) by analyzing farm statistics

→ group farms according to degrees of development and innovation potential (differentiation of target groups)

→ determine technology needs: Is 'off-the-shelf' technology available or do technologies need to be adapted to local conditions?

The result of this analysis shows the potential for innovation. Most of these innovations will be commodity-specific, i.e. either product innovations using economic opportunities or technical and organisational innovations in a given production sector. They may further be classified according to the types of technical change.

In many low-income countries, the innovation potential does not translate into an active demand for technology. Even under conditions suggesting economic benefits that applying new technology might bring, social or institutional constraints can impede the innovation. Here, it is important to distinguish between situations where the current constraints to innovation can be removed within a few years, and those where fundamental obstacles prevent a self-supporting innovation process.

It is important to clearly recognise those situations where the agricultural population operates under conditions that are not favourable for technical change. Difficulties in supporting technical change in agriculture arise when one or several of the conditions and incentives mentioned above are missing over a long period. Characteristic features of marginalised agriculture are poor farmers with little education, low prices, inelastic demand and natural locations that often only support a very extensive use, so that part of the population has to leave the agricultural sector. Marginalised and resource-poor farmers often need institutional innovations and organisational support first, before they actively demand technology.

Wherever technical progress in agriculture is underway, one or several organisations will be in place supporting the innovation process. In order to describe and analyse such a network it is necessary to clearly identify who belongs to it. Determining a boundary of the network is useful, because this helps to distinguish the internal interaction between the actors involved in the innovation process from the external framework conditions. To identify an innovation network always two iterative methodological steps have to be taken into account:

- Discovering networks of actors
- Finding and limiting boundaries of the network.

3.3. Analysis of Innovation Stakeholders and Constraints

The third stage analysing agricultural innovation from a systems perspective leads to the actual description of the system. The simplest model of an innovation system is given by a classification of stakeholders according to the elements of a service. A more detailed analysis goes on to characterise the stakeholders and identify the "innovation configuration", i.e. determining who drives the innovation and how the prime movers relate to the other stakeholders. A stakeholder analysis related to innovation could be carried out in four steps as follows:

→ Step 1: List of innovation stakeholders

Draw up a list of all persons, groups and organisations that belong to the innovation network and perform functions relevant for the innovation process. Innovation stakeholders to look for include

- **Stakeholders on the technology user side**,

- i.e. farmers and user groups such as cooperatives or village groups

- **Stakeholders on the technology supply (service) side**,

- especially public agricultural research and extension, universities, development projects and NGOs devoted to agricultural change, and private agribusiness, especially input vendors, buyers and processors of commodities.

● **Stakeholders with a supporting and mediating role in innovation**

- intermediary user organizations such as farmer organisations or commodity-specific producer associations,

- private firms providing complementary services, e.g. banks, traders, processing industries

- public agencies with a funding and steering role, especially the Ministry of Agriculture, research councils, agricultural development committees, competitive agricultural technology funds and/or local government

- professional organizations and media, especially professional organisations, universities, policy analysis institutes, journals, and international institutions such as FAO.

It is important to keep in mind, that any of these actors only become real 'stakeholders' if they have some function or interest in the innovation that the analysis is about. Wherever the screening for stakeholders shows that no specific social network for the selected innovation exists, the analyst should go back to the prior step of identifying an innovation system. Otherwise the list remains "hypothetical".

→ Step 2: Characterization of stakeholders and of their functions

This step only makes sense to the extent that the innovation process is already underway. It means to classify and rank the stakeholders providing services and supporting the innovation process according to their importance and their role in the accomplishment of an innovation. Criteria to describe functions of these stakeholders include:

- provision of technology services (research, technology development and adaptation, information and advice, delivery of inputs and equipment, training, funding of trials and technology projects)

- provision of services enabling the innovation (credit, marketing, organisation of producers, funding of specialized services, etc.)

- mediation services (political guidance, general information on the innovation problem, networking and facilitating exchange, certification, supervision of contracts and of the quality of the services provided).

The listing of functions allows matching service needs and existing service offers. It also serves to verify whether the stakeholders actually participate in the innovation process or not. This is particularly interesting in the case of research and extension agencies, which may, in fact, not perform any role for the innovation.

→ Step 3: "Innovation Configuration"

Here the leading questions are:

- Who promotes the innovation process actively?

- What are the driving forces motivating these actors?

This includes ranking the stakeholders according to their importance for and their leading role in the innovation process. Criteria are the origin of the innovation idea and of the resources - and the incentives that any stakeholder has to continue pushing for a change. It is important to also determine whether the innovation is being driven by technology users (technology pull) or by the technology providers (technology push). The two most typical situations are the innovation systems driven by the private sector, agroindustry and trade, e.g. introducing new market products and quality standards - and the innovation systems driven by development actors (NGOs or development projects, supported by public programmes).

Depending on who plays the most active role in accomplishing an innovation, we can distinguish different forms of how stakeholders relate. In the case of commodity-specific innovations, the relationships can best be described in terms of the agricultural supply chain, especially if the innovation is driven by the private sector. In the case of a development project or public programme, the most important point to look for is the source of funding.

→ Step 4: Problem analysis of the innovation system

Whereas the preceding steps of the analysis render a description of an agricultural innovation system, this step aims at identifying possible intervention points to promote the innovation and strengthen the interaction. Looking for problems, it makes sense to use the basic classification of technology users, (innovation) service providers and intermediary actors. The following **problem checklists** can be used accordingly:

● technical feasibility of the innovation

● economic and market conditions: How attractive is the market? Does the innovation fit the scale of production?

● availability of complementary goods, funds, and services

● characteristics of the technology users, their innovativeness and knowledge and their ability to actively request technology services and pay for it

● the number of users who can actually apply the technology.

Furthermore a checklist of capacity and linkage problems should be elaborated as follows:

● knowledge about the innovation potential and the applicable solutions

● service capacity, innovativeness, quality of services and professionalism of actors

● missing functions and services

● missing linkages and service relationships

● existing offers in relation to demand - coverage with services and access to them by different user groups.

A third checklist taking into account governance problems should contain following criteria:

● existence of a supply-driven, top-down governance of public research and extension agencies with little or no understanding of innovation and development pathways

● inefficiency of public service agencies and existence of "perverse" incentives for rent seeking in the public sector.

● demand for the innovation service, i.e. problems of scale, such as a small technology and input market

● missing linkages and missing support functions

● lack of public support, wherever the potential gains from innovating cannot be realized by private business or where a considerable part of the benefit is in the improvement of common goods such as commonly used natural resources.

● initial costs for developing the innovation

Many of these problems are of a general nature and not specific to any particular innovation. The problem analysis may actually point to development strategies creating the favourable conditions for innovation in the first place - and independent of a particular technological or other innovation topic. In this sense, public sector reform, especially of research and extension agencies, or activities to develop commodity supply chains can be regarded as general strategies in support of innovation and of the agricultural innovation system in a broad sense (i.e. referring to technical change in agriculture in a large sense, and not to specific commodities, groups of farmers or regions). Wherever the problems can be related to the specific innovation at stake, they provide the foundation for an intervention strategy to support both the innovation process as well as the innovation system.

3.4. Promoting Agricultural Innovation

3.4.1. Strategies of agricultural innovation

Agricultural innovations are generated by different organisations, groups or individuals. Supporting research alone is often not sufficient to actually promote innovation and technical change, because other services (input supply, marketing, credit, training etc.) are needed as well and may even be more important. In promoting innovation, it is necessary to take this pluralism into account, i.e. to include private and public actors who contribute to agricultural innovation or problem-solving. Rather than concentrating on just one of the inputs,

e.g. re-search, a strategy of promoting agricultural innovation addresses all impediments to innovation with a view to facilitating a self-sustaining innovation process. Therefore, a precondition for designing a strategy to promote agricultural innovation is to use a systems approach. Prior to developing such strategy, planners need to analyse the conditions of the innovation process, the actors involved in and the constraints to innovation. Based on a systems analysis, two development strategies can be distinguished:

(a) the promotion of linkages between different actors in order to facilitate innovations, independent of their type and particular content; and

(b) the promotion of a particular technical or organisational innovation.

Most agricultural innovations refer to product innovations or to commodity-specific technical and organisational change. Strategies to promote such innovations have to be tailored to the particular constraints identified in the respective commodity (sub) sector. Innovation in small-scale agriculture implies supporting local networking and enhancing service availability. Promoting innovation in commercial agriculture has to focus on the development of the commodity sector and especially the supply chain of the commodity in question. Strategies to promote a product innovation, i.e. the introduction of a new or modified commodity, have to concentrate on the innovation process, following a step-by-step approach. Based on the systems approach, the general possibilities for promoting innovation and developing innovation systems can be categorized into:

- **Interventions on the demand side**

These remove constraints to agricultural innovation, especially by providing market access, transport infrastructure and access to credit and inputs. An important intervention involves the organising of producers (and hence the demand for services) by forming farmer organisations or commodity-based producers' associations. Demand-side interventions will be more successful if based on hitherto undeveloped innovation potential, identifying areas and types of producers with high innovation potential.

- **Interventions on the supply side**

Capacity building for agricultural service providers (research and extension)

- **Interventions to develop the interaction between supply and demand**

Institutional arrangements for innovation and improved governance of research systems in the context of public sector services reform; leveraging R&D investment through alternative funding arrangements; integrating smallholders into innovation systems (incl. supply chains); Analysis of institutional arrangements for innovation (tool).

3.4.2. Agricultural innovations in small-scale farming

In order to identify a strategy for promoting innovations in small-scale farming, we need to focus on the economic opportunities available to small farmers. Therefore the first task in a systems analysis of small farmer innovation has to identify such economic opportunities. All subsequent steps, the further detailing of the stakeholders involved, of spatial clusters and of other aspects of the innovation process, always have to refer to the particular innovation in question. This results in a synoptic review of innovation conditions. According to systems analysis, two methodological steps needed for an intervention strategy which promotes the respective innovations or "economic opportunities" of small farmers can be distinguished:

1. Identification of intervention possibilities

The identification of strategies and measures has to build upon an analysis of the constraints to innovation. This analysis has to be done separately for each innovation. The following analytical considerations highlight different problematic aspects of the innovation process:

- Assessment of the **service needs** of the small farmers who are pursuing or intend to pursue a particular innovation and of the other actors involved in the respective innovation process. This allows a list of the required service functions to be compiled, and missing functions to be cross-checked. The basic functions are the social organisation of farmers, input supply, credit, supply of technology, and marketing.

- Assessment of the **service access** of small farmers, based upon the list of functions. The different service functions are reviewed to detect the main limiting factors. This allows the services needing strengthening to be selected, and the kind of support needed to be chosen.

- Assessment of the **capacity** and competence of the major agencies working with small farmers, especially NGOs and the government extension service. What kind of technical backup and organisational support do these organisations need? Who else could assume the supply of services?

- Assessment of **linkages** within the supply chain: is the innovation process driven by market forces? To which degree are current services subsidised by NGOs and government agencies?

- Identification of **cross-cutting problems** for innovation development. Comparing the analysis as it affects the different economic opportunities of small farmers: which problems and potentials exist independently of the particular innovations?

2. Design of support strategies

As in other service systems, interventions can best be classified according to the addressee of the intervention. One can distinguish service clients, service providers, mainly NGOs and public agricultural services; and the network of actors as a whole. Accordingly, the results of the preceding assessments have to be related to these groups of actors (The following interventions are examples taken from the case of small and marginal farm development in Bangladesh).

- Interventions referring to the **demand side** (i.e. small farmers): Supporting the creation of small farmer groups. Following up on the underlying according idea of supporting and promoting particular innovations, farmer groups can be organised around the economic opportunities and innovations selected.

- Interventions referring to the service **supply side**: Improving coverage of services needed to realise the particular innovations according to giving a better access to services for more small farmers and offering integrated complementary services; Promoting small-scale service providers, thus enhancing access to inputs and markets; Assisting agricultural extension and research institutes in order to improve their responsiveness to farmers' demands.

- Interventions facilitating **interaction** and to support the formation of supply chains: Facilitating market access and access to inputs and credit and improving linkages between the different service providers contributing to the development of economic innovations.

3.4.3. Development Problems of Agricultural Innovation Systems

There is clear evidence that the development of agricultural production and the development of agricultural service systems supporting technical change are highly interdependent processes. The history of agriculture shows that with growing production intensity, non-agricultural activities such as research, input supply, processing and information assume an ever increasing importance. The more advanced agriculture, the greater the interaction - so that over time an agricultural service system (more specifically, innovation system) develops.

Two criteria can be used to describe a functioning innovation system:

a) First of all, there needs to be a potential for technical change. Market forces, natural re-source conditions, infrastructure and social factors have to be favorable for innovation. Otherwise, no effective demand for technology and hence no incentive for funding research and extension can be expected - service organizations will tend to degenerate.

b) The second point is a balance between the size of demand and supply. A self supporting innovation system implies a reciprocal relationship between farmers and services. The organization and costs of research and extension services should be justified by the effective demand of farmers and by the proven potential for change. In the agricultural sector of developing countries these criteria often are not fulfilled. Typical problems encountered are either a low degree of the overall development of both agriculture and the service sector - or the persistence of major imbalances between demand and supply of technology showing that the service side is not well connected to the farming community. Three basic problem situations can be classified and compared to the desired state of an innovation system:

● **Situation 1: Low-level equilibrium**

The "low-level equilibrium situation is characterized by a marginalized farming community with little incentives and/or a low potential for productivity increases. Smallholder farmers operate under difficult and

heterogeneous conditions and are cut off from markets and private services - and they hardly receive attention from public extension agents neither. Technology often is not the major problem and the demand for it is low. This is a trap situation that can be found in much of Africa and also in marginal upland areas of South America and Asia.

● **Situation 2: Potential technology demand is not satisfied**

In this situation farmers do have a potential for increased productivity but fail to realize it because of lacking support services. The latent demand for technology does not induce the development of technical, extension and research services because of market failures and the low degree of service system capacity. This can be due to the public good nature of the technology needed or because demand is very smallscale, irregular and dispersed and the market size for (smallholder) technology is too small to justify the costs of private sector entry into the service market.

● **Situation 3: Public research and technology transfer systems oversized and not addressing smallholder problems**

Here, governments already fund and support public research and extension services, yet for parts of the farming population, who either do not yet possess the conditions for sustained productivity increases, are unable to voice their demands or where complementary services are missing. Producers do not react adequately to the investment in research and extension. As a result, public funds are not used efficiently - and there are few linkages. The typical problem is the dissociation of research institutions and extension agents from the farmers. The service sector is oversized compared to agricultural production.

If we want to develop research and extension in an institutionally sustainable way, the inter-dependencies between the farming side and the services side need to be carefully considered. The principle should be to work towards the evolution of an agricultural innovation system in line with the development of agricultural production. The different problem situations suggest that strategies to develop an innovation system can take quite different courses, depending on the agricultural growth potential and the origin of the disequilibrium between agricultural production and the service sector.

In a low-equilibrium situation, the development strategy has to concentrate on removing political, economic and social constraints to innovation. Research and extension organizations should redirect their services away from disciplinary research and technology transfer towards empowerment, education and poverty alleviation measures. In a situation of unsatisfied demand for technology, the emphasis is on correcting market failures and supporting service supply by private sector and Third sector organizations. It also includes strengthening public funding, steering and provision of services, so that public research and extension offers are better tailored to the needs of particular farmer groups. However, it is important to measure public investment carefully in order to avoid creating situation 3. Where public service systems are oversized, the primary strategy is to reorient and to reform public service provision and governance. The reform of public sector institutions will have to be initiated by government - and would typically include decentralization, commercialization of services, cost recovery or competitive funding.

4. Capacity Building and Management of Research Organisations

The capacity-building of research institutes is an essential aspect of strengthening national research systems. The demand for research accountability, the involvement of different stakeholders and the quest for greater research efficiency require research management tools, especially efficient planning and M&E. As public entities, research institutions in many countries have become the target of public service reform programmes. This often implies that research institutes have to go through a process of organisational change.

In many African, Asian and Latin American countries, agricultural research is centralised in national agricultural research institutes (NARI) commanding a greater share of the public funds and most of the country's available research staff. The performance of NARIs is often judged insufficient: Criticisms refer to weak links with the farming community, low levels of efficiency and the limited relevance of results for development. These problems have been noted consistently over long periods and in many low-income countries - and hence need to be interpreted as symptoms of a structural problem of poor institutional

capacity. This not only concerns the technical capability but also management and implementation procedures, research governance, organisation, and relationships with clients and funds.

"Capacity-building" generally means the internal organisation and practices of (research) organisations and institutions. Research institutions can improve by acquiring new research methods and adjusting routine management. However, these advances can often not be sustained in view of high staff turnover, a lack of incentives and bureaucratic barriers. Reforms to downsize and decentralise public sector agencies also may result in far-reaching change in NARIs. Long-term performance is therefore a question of developing institutional capacity in a wider sense. This includes technical improvements, as well as structural and cultural changes in research, strengthening service attitudes and the impact orientation of the organisation. Strategies to achieve this require different levels of capacity development, i.e. the level of individual staff qualifications, the organisational level and the legal and administrative framework within which research institutes operate. A further requirement is a gradual process approach to change, in which learning and ownership are central. People need to identify with an organisational change project and share its objectives. Organisational development implies a systematic strategy for managing change in NARIs that helps to keep a change process on track.

Research capacity also expresses itself in good performance in a number of routine management tasks that every research organisation has to pursue. Designing the procedures for recurrent management tasks can and should build on existing standards. Although the particular solutions will always have to be adapted to the conditions of the case and be part of the overall strategy for change, the basic principles remain the same. There are some management tasks in agricultural research for which tools and models have been specifically designed. They mostly refer to information management regarding decision-making like research priority setting, research programme planning, management information systems and monitoring and evaluation (M&E) of research impact.

Other domains of research management include managing human resources (training, rewards, pay scales, performance assessment) and funds (financial planning, budgeting, allocation of funds, accounting). Management expertise in these fields is less specific. The most important source for standard techniques of research management is the International Service for National Agricultural Research (ISNAR) in Den Haag. A major criticism of research in less developed countries is the lack of relevance of results for the farming community. Many development projects thus concentrate on the capacity of research organisations to address development issues and the needs of clients. Client orientation of research is a multi-dimensional concept that involves changes in governance structures, close linkages of researchers with users, the application of participatory research methods, and the adoption of adequate approaches to planning, monitoring and evaluation (M&E). The concept is also related to the idea of impact orientation (see chapter 6).

5. Client-Oriented Research

Applied agricultural research is increasingly being regarded as an agricultural service acting upon demand and seeking to develop close links with clients. Experience has shown that research becomes more effective when it takes local knowledge into account and actively seeks to cooperate with farmers. Agricultural research and extension have to respond to the demand for assistance in solving agricultural problems. It is the farmers who finally decide whether a change proposed to them actually becomes a useful innovation or not. Applying the service concept to research means intervening at the following different levels:

1.) Strengthening farmer demand for services:

The functioning of a service relationship critically depends on demand. The development of the private sector and rural civil society, including farmers' associations and local communities, is the key to client-oriented research, since these organisations play an important role in formulating the demand for research services. Farmers' organisations also have the potential to raise money for technical improvements, enabling them to become service providers themselves.

2.) Improving linkage to farmers and other clients:

Rendering a service implies establishing and maintaining linkages with clients during the course of research projects. According to the stages of the research process (planning, implementation, communication of results), the type of research partner and the function of the exchange (decision-making, collaborative activities, exchange of resources), there are a broad variety of possibilities to organise linkage between research and clients.

3.) Using participatory approaches to conduct research activities:

Researchers have to ensure that their results and that the technologies generated take the constraints under which farmers work (e.g. their access to land, labour, capital and markets and the social and cultural conditions of farming) into account. This is particularly relevant in the case of poor farmers facing constraints. Instead of transferring preconceived solutions to farmers, researchers and farmers have to combine local knowledge and scientific insight.

4.) Improving research management:

The client orientation of a research institute also expresses itself in the research agenda and in research management including staff training and reward system, planning, M&E, impact assessment and public relations.

5.1. Research-extension linkages

A basic premise underlying the concept of linkages between research and extension is that although these actors are linked by their focus on developing and delivering new or existing technology, they are working largely separately and not always in a compatible manner. Research and practice on linkage looks at agricultural research and extension and other actors such as farmers, farmer organizations, NGOs, policy-makers, commercial companies, etc. as participants in an overall agricultural knowledge and information system (AKIS) or an agricultural technology system (ATS). Linkages connect the institutions and functions of the components so that they can achieve mutual beneficial synergies making the total impact of their joint activities greater than the sum of their individual impacts. **Linkages** form bridges between actors (research, extension, farmers, NGOs etc.) and the exchange of resources (information, money, labour, materials etc.) between institutions and personnel. **Linkage mechanisms** are organisational procedures used to establish and improve linkages among actors.

Studies from the International Service for National Agricultural Research (ISNAR) found out that linkage activities need to be covered by adequate resources. Actors are directly responsible for funding their own activities. When other actors are involved the return on investment has to be worthwhile, especially in case of scarcity. If linkage activities are to take place, fun-ding for them has to be specified. The participation of all relevant actors is crucial if the sys-tem is to achieve its objectives. Therefore, research-technology transfer linkages inevitably have to embrace the participation of farmers and farmers' organisations if relevant and responsive technologies are to be generated. Linkage situations are dynamic and specific to each particular system. Thus the diagnosis of linkage problems, the choice of linkage mechanisms as well as their application has to refrain from recipes and must instead be pragmatic.

5.2. Farmer village research committees

Good linkages between research and extension are not a guarantee that relevant new technologies will regularly be made available to farmers, especially to resource-poor farmers. Input from farmers into the technology process is a crucial ingredient for the successful development of new technologies. RÖLING (1990) argues convincingly of the desirability of user input at each point at which information or technology is transformed or adapted. In fact, farming systems approaches were largely adopted to address this issue. However, while those approaches gave research a better understanding of the farming system, they did not give farmers a voice regarding research. The idea of village research committees aims to fill this gap. Often such committees are initiated by research and therefore continue to be village platforms for testing and disseminating technologies. Not withstanding their origin, village research committees are effective in raising awareness and encouraging farmers to feel enthusiastic about research results.

Experience in Kenya with farmer research committees has shown that the scope for farmer representatives to influence research through committees set up by research is significant but limited by the size of the committees in relation to the size and diversity of the farming community. Farmers' organisations, therefore, can complement this forum by having representatives of research and extension in their own committees. This way they can clearly express the needs of their members and allow researchers and extension workers to get a fuller picture of the problems form their point of view (WUYTS-FIVAWO, 1995).

In Colombia, CIAT was instrumental in establishing Village Research Committees or Comites de Investigación Agropecuaria Local (CIAL) in 1990. Additional CIALs have also been formed in Bolivia, Ecuador, Peru and Honduras. The strategy of the project is to implement participatory research methods for adaptive technology testing. This is done through the formation of locally elected committees, which manage and conduct research on behalf of the community as a whole. The local communities are responsible for the election of the committees, setting the research agenda, and helping evaluate the results. The committees carry out technology testing together with public sector agricultural research and extension agencies, non-governmental organisations, and farmer cooperatives. Part of the project also includes the development of courses and materials to train farmers and staff of various agencies. A number of the CIALs have evolved into significant local seed production enterprises. The committees as a group have now formed their own corporation, enhancing information exchange and putting them on an independent financial footing. One major side effect of the project is that farmers are winning respect as they show their capability to manage research. This respect catalyzes a gradual reorientation of the priorities of bureaucratic institutions. While questions about the long-term viability of CIALs still remain answered, it is already apparent that farmers can manage and conduct research on behalf of the community as a whole and that they are also quite capable of setting research agendas and evaluating results (CGIAR, 1995).

6. Impact Assessment of Agricultural Research

Impact assessment (IA) has recently attracted more attention in agricultural research due to increasing budget pressures and the subsequent need to account for the past and justify new investments. IA is firstly more process-oriented and realistic, focusing on learning and communication and secondly is perceived as a means to increase the overall impact orientation of research institutes. Researchers benefit from impact assessment (IA) in two ways: they can show their accountability to their patrons in securing funds, and they can improve their understanding of what is needed to achieve an impact. Evaluation can then be used to improve on any relevant aspect of research, be it the proposal of new projects, planning, staffing, or the partnership with clients.

6.1. Concepts of Impact Assessment in Research

The term "research impact" refers to the social, economic, environmental and institutional changes emerging from agricultural research and technology development. Efforts to improve the prospects for research impact should build on two fundamental perspectives:

1. Analysis of impact: Assessing impact confronts a number of fundamental conceptual and methodological problems, since agricultural innovation is a multidimensional and dynamic process. It is virtually impossible to grasp all the relevant factors, let alone control them. The more aggregated the impact measure, the more conditions (and actors) external to research, such as markets or policy, need to be taken into consideration.

2. Management of impact: IA is a very important prerequisite for the ability of research to have a verifiable impact. An impact-oriented research institution not only observes and verifies its impacts; it also addresses the internal organisational conditions for achieving impact.

Generally, the term "impact orientation" is characteristic to research organisations which are focused on achieving relevant and high-quality results serving the demand of clients and public donors. Achieving impact is reflected in any of its activities, ranging from conducting experiments to administration and management. Ideally, all members of the research organisation would be concerned with their contribution to impact. Impact orientation thus is a structural phenomenon indicating the general institutional capacity of agricultural research. The term "impact orientation" appears to be closely related to the trend in development towards good

governance and a more accountable and service-minded government. (e.g. World Bank, "Monitoring and Evaluation Capacity Development in Africa", 1999).

Conventionally, impacts are classified following the sequence of steps that leads from re-search to agricultural development. Research activities produce an output, the immediate research result, which leads to an outcome, i.e. the application of new knowledge or technology. Technology use, in turn, contributes to benefits in combination with other factors, e.g. rising productivity. These changes are part of the wider rural development process, which implies macro-level changes, e.g. an increasing level of welfare or an enhanced quality of natural resources. Macro-level, aggregate change can be interpreted as an impact of re-search, to the extent that it can be related to prior research outputs. The whole process of achieving impact can be conceptualised in the generic model of an **impact pathway**. For each particular research project, the impact pathway looks different. Continuing the impact pathway and away from the initial process, i.e. a particular research activity, the variety and number of factors relevant for the innovation increases. There is an "impact gap" between the different stages, because earlier stages are not the only causal factors for subsequent ones. Whether aggregate impact is achieved or not depends on a whole set of variables external to the research process, such as the functioning of rural input and commodity markets, the status of education, means of transport, means of communication, and the functioning of extension services. The relative weight of research thus declines along the pathway. Looking at the pathway from the opposite direction, impact gaps appear as "attribution gaps": The observed changes become less and less attributable to the research projects contributing to it, and more difficult to distinguish from the impact of other development efforts (cf. GTZ evaluation model, Kuby). Impact or attribution gaps are manifestations of the more fundamental conceptual problems modelling impact. Impact is apparent within an agricultural innovation process in which technology play a role depending on the type of innovation. Many problems that can benefit from research only become visible during this pro-cess. While it is important to understand the dynamics of agricultural innovation, this often involves complex issues and raises problems of data availability. At the same time, skills, human resources and money tend to be very scarce. These problems have consequences in designing IA, i.e.

- Research needs to be aware that it cannot fully control the technological change process and its downstream effects. When planning and conducting research projects it has to be taken into account that the impact depends on many other factors besides the technologies made available by agricultural research. Realistic objectives for impact assessment, taking into account attribution and data problems have to be designed.

- IA has to follow a learning curve leading to a gradual understanding of impact. The key point is to create feedback loops between observing change and implementing research projects, and between the clients of research and the researchers themselves.

6.2. Management of Impact Assessment

Managing impact orientation means combining the approaches already used (e.g. research planning or participatory research methods) with complementary efforts, especially systematic IA. The different dimensions of proper research management should be united on the impact perspective. Researchers can increase their chances of having an impact by ad-dressing the conditions of success at their end of the impact pathway directly. Because of the impact (or attribution) gaps, it is not possible to manage research impact as such development impact being beyond the control of a research institute, but research managers can do much to create the right framework conditions. This is often independent of the specific impact pathway in question.

Just as in other services, capacity development for impact orientation in research has to take place at different levels, i.e. with regard to:

- the institutional framework, under which research operates, e.g. by introducing competitive funding mechanisms that provide an incentive to become more impact-oriented
- the internal organisation of research institutes, institutionalising IA procedures, and
- the qualification of individual researchers and research managers (cf. the concept of capacity development).

A fully-fledged impact monitoring system for individual research programmes is costly, how-ever. IA studies may just as well concentrate on intermediate steps and partial processes of the impact pathway, such as the technology transfer process, technology adoption or social change in rural communities. Whichever

perspective is taken, studies will contribute to a better understanding of how research impact is achieved, as long as they fit into the particular impact pathway in question. Different types of evaluation and IA studies according to segments of the impact pathway exist. Studies look forward (ex ante), accompany ongoing change (monitoring) or look back (ex post) as shown in the following examples:

1. Assessment of the research process (from research activities to research output):

This level includes M&E activities such as

- activity monitoring of research,
- financial audits (ex-post),
- external/ internal reviews of research programmes (ex post)

2. Assessment of the agricultural innovation process (from research output to benefits): Types of IA studies include:

- technology adoption studies (mostly ex post, some ex ante)
- innovation studies on particular commodities (monitoring, ex post)
- innovation studies on farming systems or resource use (monitoring, ex post)
- farm household analyses (monitoring, some ex post)

3. Assessment of the rural development process (from benefits to macro-level change):

This includes:

- economic impact assessment (cost-benefit analyses, ex-ante or ex-post)
- social and environmental impact assessment (monitoring, ex post)
- poverty studies (monitoring, ex post).

Guidelines of IA are numerous focussing on different field of actions. However, the following guidelines can be seen as the general sequence of IA studies:

1. Clarify objectives and subject of IA / impact monitoring
2. Define impact areas and core issues
3. Formulate impact hypotheses (referring to the impact pathway)
4. Select indicators to be measured
5. Select observation methods
6. Collect and analyse data
7. Communicate results and manage information.

Each step may be differentiated further into more detailed tasks. For example, step 5 can be broken down into procedures to design the survey, develop or adapt methods, select cost-effective tools etc. The sequence constitutes, in fact, a cycle. After completion of an IA study, results should be fed back into the next round. In an ongoing evaluation (impact monitoring) of research, the procedures can be adjusted to the research project cycle: Steps 1 to 3 are close to the research planning stage, steps 4 - 6 accompany research implementation, and step 7 feeds into final reports. Every IA study has to be designed separately according to the objectives (step 1) and taking into account the constraints of the organisation. Methodological choices are particularly large for steps 4 (indicators) and 6 (data collection and analysis). Data collection methods range from village group discussions to formal surveys or the measurement of physical variables. Analytical tools to be used for IA comprise qualitative judgements and complex modelling approaches likewise. The relevant set of tools in IA depends on the field of innovation: it is evident that impact hypotheses, the set of indicators and analytical methods correspond to the type of innovation at stake. Assessing the impact of plant breeding programmes, of farming systems research or research on agri-cultural policy issues all require specific analytical techniques.

IA can use both qualitative and quantitative data. Any IA concept has to start by using open-ended, qualitative methods to identify the issues and stakeholders. Qualitative methods are useful to focus the problems and find the right questions and hypotheses on which to build IA. Examples of such methods include the "impact

mapping" and flow charts, RRA tools (rapid rural appraisal), the "paper and pencil computer", expert consultations, interviews and screening of secondary material, e.g. on the Internet. Qualitative approaches are also necessary to elicit the value research users attach to the outcome and benefits at stake. The use of quantitative methods (formal surveys with statistical interpretations or economic modelling) adds value when the impact pathways can be described precisely and impacts can indeed be measured. They are indispensable when assessing changes at the macroeconomic level, although qualitative judgement will be necessary in most cases to plausibly link macro-level change to the lower levels in the impact pathway.

The views of farmers and other research clients are a valuable source of information on the development process and provide the basis for valuing the ongoing change. After all, IA needs to take the perceptions of those who are to benefit from research into account. Participatory methods are used to grasp the perspective of research beneficiaries. Examples include participatory rural appraisal (PRA) techniques, the "SWAP" method (analysis of strengths, weaknesses, aims, problems), participatory action research, stakeholder work-shops and village meetings. However, participatory evaluations also have limits, as statements of small groups cannot easily be extrapolated and the perceptions of different groups may be in conflict. Therefore expert (desk) studies are useful to clarify the issues and come to a balanced judgement.

6.3. Institutionalising Impact Assessment in Research

Achieving impact orientation implies treating IA as a permanent task. Research institutions have to create the internal capacity to carry out IA regularly. The guiding principle for institutionalising IA as a regular practice is that the amount of resources devoted to IA needs to be justified by the benefits of impact studies. Designing procedures for IA depends on the objectives pursued. The objectives, e.g. accounting for public money vis-à-vis the Ministry of Agriculture or preparing research proposals and medium-term plans have to be achieved in the most cost-effective way. Organisational arrangements for conducting regular IAs include the need to:

- Define the purpose of impact assessment (accountability and/or planning research)
- Develop a framework for IA, distinguishing tasks at different institutional levels (research project or programme level, institute level, research customers) and along the research cycle (ex ante IA, impact monitoring, ex post evaluation). For each level, state the responsibilities, tasks and frequency of studies.
- Wherever possible, and especially when assessing aggregate development change, form alliances, dividing IA tasks with non-research partners working to achieve the same development objectives as research
- Select a cost-effective methodology for each task, based on the available guidelines and methods for impact assessment
- Develop the IA skills of researchers
- Actually assign responsibilities and allocate time and financial resources for data collection and analysis. As a general rule, limit the expense for IA purposes to 5% of the total investment sum in question
- Introduce an information system for the storage and retrieval of IA data.

An important aspect of institutionalising IA and impact orientation is to close the "management cycle". IA is part of a larger managerial or administrative process connecting planning, implementation, evaluation and (re)planning. An important concept here is the PM&E (Planning, Monitoring and Evaluation) cycle. The decisive point is that IA should be used as a management instrument to prepare decisions and improve research.

An important key factor for the success of Research & Development activities as well as for the analysis of their impact is ensuring close cooperation with the users of research services. Stakeholders have an important role in the design stage of IA, initiating and demanding IA work, during an IA study, as participants providing information and after completion of the studies, by receiving and using the results.
Institutionalising IA therefore implies linking up with farmers, projects, NGOs, government services and rural organisations involved in the same fields of rural development and impact pathways as the research institutes. Conducting IA is a good occasion to call stakeholder meetings and communicate with development partners.

7. Literature

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