OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

19664

HOW TO REALIZE THE POTENTIAL OF BIOTECHNOLOGY FOR RURAL SMALL-SCALE PRODUCERS IN DEVELOPING COUNTRIES

Background document for the Expert Group Meeting on "Applications of Biotechnology to Food Processing in Africa"
Ibadan, Nigeria, 16-20 December, 1991

Jacqueline E.W. Broerse
~~Theo van de Sande~~
Joske F.G. Bunders

Department of Biology and Society
Vrije Universiteit Amsterdam
The Netherlands

1. Introduction

The past decade, there is a growing interest in small-scale enterprises (SSEs) as a tool tc stimulate the overall development process in developing countries. The major reason underlying this trend is disappointment with the performance of modern large-scale industries in developing countries; during the 70s, it became evident that large-scale enterprises did not stimulate a wide ranging development process to the extent expected (Teszler, 1989a). Evidence suggests that small-scale enterprises are often inherently more efficient than large-scale enterprises in adding value to local human and material resources. Generally, per unit of investment, small-scale enterprises proportionately create more employment, produce more products that can be used for local consumption, and result in greater increases in local economic activity than large enterprises (de Wilde, 1988).

In this paper, we will concentrate on rural SSEs which are based around the production of inputs (backward production linkages) and the processing of outputs (forward production linkages) of the agricultural sector. Such industries furnish employment and income for the small-scale farmers, as well as for the landsless for whom casual agricultural labouring is generally the only money earner (Lewis, 1987). The rural small-scale enterprise sector derives its strength from its complementarity; it increases the development potential of the agricultural sector as well as other sectors of the economy, it assists in stemming the migratory flow to already overcrowded urban areas and, thus, it contributes to an integrated development process (Ranis, 1990; RSIE, 1988; Teszler, 1989b).

Technological change can be considered one of the prime carriers of economic development (Freeman, 1989) and could also be a crucial factor in the establishment and improvement of SSEs, but only if the technology is appropriate. A technology is considered appropriate when it both takes into account the prevailing conditions and makes the best use of local available resources (ILO, 1980, Bunders and Broerse, 1991). Biotechnology, being a flexible and adaptable technology, could be an appropriate technology for the establishment and improvement of rural rural SSEs.

Recognizing, in theory, that rural SSEs can contribute meaningfully to the alleviation of rural poverty and that biotechnology can enhance the establishment and improvement of such enterprises, does not imply automatically that as such it will be realized. Its realization very much depends on the context; on national and international policies towards rural development and towards R&D methodologies, and on the systematic participation of the rural poor as users, producers and beneficiaries of these new technologies. In order to organize and structure a process to identify, formulate and prioritize appropriate biotechnological innovations for small-scale producers, to create an enabling environment for SSEs and to achieve information exchange between relevant people and groups, a model -the interactive bottom-up approach- will be presented in this paper. We will also discuss the consequences of applying such an approach in international research centres.

2. Small-scale enterprises: their importance and problems

SSEs have played an important role in developing countries for a long time. About 10% of the rural population in developing countries is completely dependent on small-scale industrial activities. Furthermore, it is estimated that 10-20% of the male and 50% of the female rural population derives an additional income from rural SSEs (Veenstra, 1991). However, up till the 1980s, this role was not recognized by policy-makers in developing countries and donor agencies. Instead, in their industrial development strategies they preferred to concentrate on establishing large-scale enterprises as the cornerstone for development and growth (RSIE, 1988; Teszler and Molenaar, 1989). In particular this has been the case in a number of countries in Sub-Saharan Africa where a presumed lack of entrepreneurial skills has stimulated the establishment of government controlled urban based parastatals as the spearheads of industrial modernization (Teszler and Molenaar, 1989).

However, a modern large-scale industrial sector of any significance is beyond the reach of many developing countries because it (i) involves high investment and maintenance costs, (ii) depends on specialized (urban-based) services, and imported technologies and inputs, (iii) demands good physical and social infrastructure,and (iv) demands access to international markets (Teszler, 1989a). This sector provides no adequate solution to the problem of unemployment, its derived spread effects on other sectors of the economy are limited, and its products do not reach the population at large. As a consequence of the disappointing results obtained by emphasizing large-scale, modernization strategies for industrialization, small-scale industry came increasingly to be considered as a viable alternative or at least as a vital element of an integrated industrial structure, which in turn would promote economic development (RSIE, 1988; Teszler, 1989a).

In general SSEs produce simple implements and consumer goods (such as processed foods, agricultural inputs, clothing, footwear, household utensils and wooden furniture). Usually the quality of these products cannot measure up to the branded output of large-scale enterprises, but the relatively low price they command brings them within the reach of large segments of the population (Teszler, 1989a). SSEs usually make use of existing artisan traditions and knowledge, make use of locally available materials, and apply labour-intensive production methods. SSEs are less dependent than large-scale enterprises on specialized services which in most developing countries tend to be found almost exclusively in urban areas. SSEs are, thus, more footlose (Teszler, 1989a).

Problems in the SSE sector occur at three different levels:

1. *Entrepreneurial level:* Enterpreneurial aspirations of the rural poor in developing countries often go unrealized because these people lack access to financing, management skills, knowledge of appropriate technologies suitable for commercialization and an understanding of the potential market for the product (O'Donnell and Hyman, 1987).
2. *Sectoral level:* The basic problem that still needs to be fully appreciated by many policy-makers is the importance of decentralized industrial and service activities in the rural areas, interacting with agriculture and urban industry. In most of the developing

countries there still exists a profound lack of support of the SSE sector in macro-economic, trade and industrialization policies (Ranis, 1990). Furthermore, the SSE sector is faced with low productivity, competition of larger scale industries, distribution problems, low technological level, and limited development of trade networks (Veenstra, 1991).
3. *Macro-economic level:* The development of a successful SSE sector is often hampered by developments on the macro-economic level; e.g. limited economic growth, limited economic and industrial development, poor physical and social infrastructure, political instability, large population growth and limited institutional facilities.

3. The appropriateness of biotechnology

Biotechnology can be defined as the integrated use of molecular genetics, biochemistry, microbiology and process technology emloying micro-organisms, parts of micro-organisms, or cells and tissues of higher organisms to supply goods and services (DGIS, 1989). Biotechnology is neither a scientific discipline nor an industry but a continuum of technologies ranging from highly sophisticated and complex techniques such as enzyme and cell immobilization and recombinant DNA technology to less sophisticated and simpler techniques such as food processing, plant tissue culture and plant inoculation.

Potential of biotechnology

The more advanced biotechnologies can be commercially characterized as high risk, high gain investments, which promise substantial returns on successful investments. Research and development time is usually long and expensive. Often it is the 'high tech' end of the biotechnology gradient that receives the most attention. Yet, despite their current scientific sophistication, they may not be the best fit for a problem in a given location. Even though 'high-tech' biotechnology may ultimately have pervasive effects, the time-lags in research, development, diffusion, investments, education and training for the innumerable potential applications are such that these can hardly occur before the 21st century. Genetic engineering today is still at the stage of computer technology in the 1950s (Freeman, 1989). This is not to argue that 'high-tech' biotechnology has no relevance to the development and improvement of SSEs, but to underline that it is expensive and that the benefits are far from guaranteed on the short and medium term. The emphasis on 'high tech' biotechnology may divert scarce resources from research on 'traditional' biotechnology that may be more appropriate (Persley, 1990).

More immediate results can be expected from 'traditional' biotechnologies. Several of these technologies are well-known, 'mature' and ready for further development towards commercialization. Traditional biotechnological processes are found in the area of food and nutrition, particularly in the manufacture of foodstuffs and beverages. These processes can be improved: their efficiency and yield can be increased, through the selection of more productive microbial strains, the control of culture conditions, and through the adaptation of the fermentation products to the evolution of food habits and to the consumers' changing tastes (Doele, *et al.*, 1987; Sasson, 1988). Other interesting areas for commercialization of biotechnologies are agricultural inputs which increase yields and/or reduce requirements of capital-intensive inputs; e.g. virus-free plants (plant tissue culture), biofertilizers, biopesticides, livestock feed from crop by-products and mushroom cultivation. These promising biotechnologies, however, usually still need extensive field demonstration and assimilation into local practices before efforts at commercial small-scale production can be made. Some of the technologies may have already demonstrated local commercial success, such as rhizobium inoculant technology and tissue culture, but such success is on a limited scale and does not immediately translate into expanded activity and international transferability.

Flexible and adaptable

Traditional production methods and technologies are still of enormous importance within the rural SSE sector in developing countries. These methods and technologies are integrated in local social structures and are in harmony with the local culture. The strenghtening of the technological capacity of the SSE sector should be built up from the grass-roots level to meet the producers' needs and skills. The recovery of the traditional technological base involves linking modern science with traditional technologies, in order to upgrade them selectively through the systematic application of the scientific method, and through the integration of products of science-related technology with those of traditional activities (ILO, 1980).

Since biotechnology can be 'tuned' to very localized problems, it contains elements of an appropriate technology for the establishment and improvement of rural small-scale enterprises. In contrast to most biotechnological research and development itself, many of its applications are inexpensive, uncomplicated and do not require capital- and energy-intensive inputs. Biotechnology is often flexible in scale and in the type of technology used, facilitating small-scale, decentralized application and adaption to the special circumstances of SSEs (Broerse, 1990). Moreover, biotechnology could be linked to indigenous knowledge, existing practice and local initiatives, given the age-old use of some biotechnologies in developing countries (Bunders and Broerse, 1991).

In sum, many of the traditional biotechnologies are in potential appropriate for application in the SSE sector; they are amenable to labour-intensive, decentralized, small-scale production, requiring a minimal invesiment in sophisticated equipment and seem adaptable to specific local needs.

4. Constraints for development of appropriate biotechnology

Recognizing the potential value of biotechnology for small-scale producers does not imply that it will be realized. The majority of biotechnological research and development (R&D) efforts are done in areas where it can lead to commercially attractive applications for which large and lucrative markets exist, e.g. diagnostics (immunological tests and DNA probes), human pharmaceuticals and animal vaccines, plant improvement (the addition of single gene traits such as herbicide- or pest-resistance to hybrid seeds) and food processing involving mass production of standardized commodities (Broerse, 1990).

As we have seen in the previous paragraph, efforts in biotechnology need not be confined to generating innovations that are high yielding in high input systems affordable only by resource-rich producers or that are capital-intensive useful only in large-scale urban industries. There are innumerable ways in which international and national research systems can use biotechnology to make substantial contributions to raising productivity in sustainable, low risk, low-input farming systems and rural small-scale industries in developing countries (Joffe and Greeley, 1990). There are, however, many factors which hamper the development of appropriate biotechnology for small-scale producers.

Focus of research in industrialized countries

The most active groups in biotechnology R&D are government institutions (universities and public research institutes) and private companies (research firms and multinationals in the chemical, agrochemical, pharmaceutical and food sectors) in industrialized countries. Much of the fundamental molecular biological and genetic research underlying modern biotechnology has been developed in governmental institutions. The private sector, too, has become interested in biotechnology. Companies, large corporations in particular, have rapidly built ties with universities and public research institutes. Waning government research funding in many developed countries has put increased pressure on universities and public research institutes to engage in contract research. Research contracts add exclusivity of access to public sector research and provide additional input for private sector development of products. Through contract research and the acquisition of biotechnological research firms, several multinationals have attained a dominant position in biotechnology, a position protected by intellectual property rights (patents) (Broerse, 1990; Clark and Juma, 1991; Junne, 1987; Kenney, 1986).

Governments are also heavily involved in biotechnology. In most industrialized countries (e.g. USA, Japan, United Kingdom, France, Germany and the Netherlands) the development of biotechology has high priority. Governments endeavour to stimulate and influence development in biotechnology through grants both to industry and public institutions. The priorities addressed by these programmes usually stem from market analyses which identify the problems and interests of industry.

Thus, current biotechnological R&D programmes in industrialized countries are, by and large, guided by the economic considerations of large corporations (and governments). Hence, the focus of biotechnological R&D in industrialized countries is on resource-rich producers and large-scale urban industries.

Limited scientific manpower and funds for operations in Africa

A large proportion of scientists in Africa do not hold postgraduate qualifications. Moreover, between 1960 and 1980, real expenditure per African researcher has decreased by 25 per cent. In contrast, in developed countries, expenditure per researcher increased by 70 per cent in the same period and from a much higher baseline.

Due to this lack of qualified researchers and funds it is very difficult to establish a critical mass in biotechnological research in Africa.

Focus of research in African countries

Emphasis is almost never placed in policy and research agendas of African countries on the generation of appropriate biotechnological innovations for small-scale producers. Scientific research in most African countries started earlier this century during the colonial eras. Consequently, research in general was (and is) usually oriented towards the 'colonial' and export-oriented production on large farms and industries. These resource-rich and large-scale producers are able to communicate their needs to researchers, either directly or through producers' organizations, and assess and adapt the recommendations which come back to them. These producers often have the economic and political powere to help researchers and policy-makers in the advancement of their careers.

In addition, it is often assumed that mainstream research benefits all producers, including small-scale producers. Through a so-called 'trickle-down effect' the demands of small-scale producers will also be satisfied. However, this phenomenon rarely occurs, largely because the small-scale producers cannot afford the costly materials and services associated with these innovations. Even when 'trickle-down' does occur, it can have unfortunate and unforeseen side-effects.

Lack of power of small-scale producers

Small-scale producers have much knowledge of their enviornment and experience of how to use that environment. They are not, as might be assumed, innately conservative. On the contrary, they are usually active and creative in experimenting with local innovations. However, largely bereft of purchasing power, external innovations of potential benefit do not reach them through the commercial process (Bunders and Broerse, 1991). Dispersed, isolated and poor, their influence on the political agenda, even within their own countries, is minimal (World Bank, 1990). Small-scale, resource-poor producers, particularly those in the rural areas, have had no effective organizations through which to get access to relevant information from formal research and development, and to articulate their problems and needs.

Lack of communication

In cases where small-scale producers are a specific target for research and development, the innovations are rarely successfully adopted. The many breaks in the chain between research and small-scale producers, and the chasms of education, class, and objectives that stand between the various individuals and organizations involved make successful technology development an unlikely prospect (Ewell, 1989). In general, researchers and policy-makers are ignorant of the problems and needs of small-scale producers. As a consequence, researchers and policy-makers set priorities and goals through conclusions they draw from their own theoretical models and value systems of what ought to be appropriate and not by involving end users directly in the process of problem formulation. 'Appropriateness' on paper is not the same thing as appropriateness in practice. As a result some of the most impeccably 'practical' pieces of research end up with disappointingly few adopters. Meanwhile the majority of African producers continue to rely on their own systems of knowledge and research procedures -systems and procedures of which scientists in the 'formal' sector are often quite unaware (Richards, 1985).

In sum, biotechnology is oriented to the developed world. Many African countries are hardly capable of establishing a critical mass in biotechnology research due to lack of qualified manpower and funds. From scientific discovery onwards, biotechnology leads towards the profitable markets of high technology industries and intensive agriculture. Biotechnological applications currently in development will bring innovations mainly to the group of capital-rich, often large-scale producers (Bunders and Broerse, 1991). In addition, governmental policies and practices often end up favoring large-scale enterprises over small-scale enterprises. In most developing countries these developments are not accompanied by successful creation of employment. In practise, biotechnology seems destined to increase the gap between the rich and the poor as well as the migration to urban areas.

5. Conditions for development of appropriate biotechnology

Discussions on biotechnology tend to be more concerned with its technological potential and less concerned with the mechanisms by which poor beneficiaries might realize such potential. However, biotechnology has only much to offer the developing world if it is adopted by the people it is intended to help. The institutional bases for organization of new technology adoption, such as end-user participation in setting research priorities, the ability of extension services and the marketing infrastructure (for both inputs and outputs) to reach small-scale producers, the targeting of credit, and the distribution of benefits will, thus, be more important determinants of poverty-related effects of technology diffusion than the characteristics of biotechnology. An effective poverty-focused biotechnology intervention holds enormous potential only if developed in an institutional context which empowers poor people themselves and allows them to control decisions on the technology adaptation (Joffe and Greeley, 1990). It is of great importance that scientists and technologists come to the realization that the social, political, and economic environments in which science and technology is to be embedded in the developing countries are enormously complex and risk-prone, and different from those which pertain in the developed world (Doele, *et al.*, 1987). In order to realize the potential of biotechnology for the establishment and improvement of SSEs, a successful approach to technology development will have to fullfil the following four conditions:

1. *Participatory, bottom-up perspective:* An approach on the generation of new technologies should be based on the participation of the target group and a thorough understanding of the problems of the target group, their interests and their production systems. A participatory, 'bottom-up' perspective should be the starting point for

national policy, programme and project formulation with respect to applications of biotechnology to ensure that benefits from the resulting productivity improvements are not captured disproportionately by private interests, urban consumers and resource-rich producers. In practice, this perspective requires that the objective of governments is not to 'build a biotechnology capacity at all costs' but to target poverty alleviation first and then to consider any possible role for biotechnology (Joffe and Greeley, 1990).

2. *Technical feasibility:* Innovations should be feasible - that is, the expected output is achievable both scientifically and technically and in terms of its dissemination to the target group. A new enterprise or technology is risky; it takes time away from activities with known outcomes, even if the efficiency of the known activity is very low (de Wilde, 1987). Most entrepreneurs operating in materially poor conditions can only afford a small margin of risk. A combination of appropriateness and feasibility makes an innovation implementable. Furthermore, the biotechnological innovation should have comparative advantage in implementability, problem-solving capacity and cost effectiveness over other options.

3. *Effective policy measures:* Policy-makers should be convinced of SSEs' potential role in development as well as the potential of biotechnology to contribute to the SSE sector. This will ensure that effective policy measures to create an enhancing environment for the development of SSEs and appropriate biotechnology will at least be considered.

4. *Exchange of information:* The exchange of information between different groups is crucial. Decision-making on biotechnology for SSEs is a very complex issue involving different scientific fields and different organizations and social groups. Without effective exchange of information and materials, it is possible neither to plan nor to coordinate the necessary activities, thus strongly hampering effective decision-making. First of all, the results of the research carried out in the different scientific fields are not systematically brought into relation with each other and made accessible to decision makers. Secondly, the different organizations and social groups involved -scientists, expert consultants, donor organizations, policy-makers, extension workers, entrepreneurs and farmers and the organizations which represent and/or work with them- often have different perceptions of what the problems and the appropriate solutions are. All these groups have specific relevant expertise, but lack other types of useful knowledge. Since information exchange between these groups usually is very limited, decision-making on biotechnology in many countries is reduced to an ad hoc process depending on the incidental suggestions of those closest to the decision makers.

In sum, a successful approach to technology development should simultaneously (i) identify, formulate and prioritize appropriate and feasible biotechnological innovations for small-scale producers which have a comparative advantage, (ii) create an enabling environment for SSEs and biotechnological research and (iii) achieve information exchange between entrepreneurs, farmers, scientists, policy-makers, extensionists, and other relevant groups. In the following paragraph, we will discuss an approach specifically designed to organize and structure such a process: the interactive bottom-up approach.

6. The Interactive Bottom-up Approach*

The 'interactive bottom-up approach' is a model developed by the Department of Biology and Society of the Vrije Universiteit Amsterdam to assess the use of biotechnology for small-scale producers in developing countries. The approach avoids technology-push by drawing on the knowledge and opinions not only of scientists, policy-makers and expert consultants, but also that of end-users and the organizations which represent and/or work with them. Central in this model is the use of two different but closely cooperating teams: a formal interdisciplinary team to bridge the gap between providers of innovations and the potential users, and an informal team on the spot, consisting of people sharing the same commitment, to specify and broadly justify the ideas.

In this model three phases can be distinguished: the preparatory phase, the interaction phase (public debate) and the phase of institutionalization. Depending on the context of the country, the time for preparation and debate may be 5-10 months.

1. Preparation

In this phase, ideas are elaborated. In our case, the idea is that biotechnology can contribute to sustainable rural development. The output of this phase is the formulation and prioritization of problems and research areas, and guidelines for the construction and assessment of new projects. Activities which take place in the preparation phase are:

1. Establishing a formal interdisciplinary team to catalyse and support decision-making on biotechnology for small-scale producers;
2. Preparing an overview of relevant literature;
3. Generating information through interviews with the view to establish the basis of traditional production systems and to enhance these systems through the application of appropriate biotechnology;
4. Establishing an informal team;
5. Exchanging information within the informal team; and
6. Integrating results by specifying and justifying the ideas.

The formal interdisciplinary team (whose members should at least cover the disciplines biotechnology, technology assessment and development studies) will collect information through literature study and interviews from as many different sources as possible. This should encompass information on the problems and interests of small-scale farmers and entrepreneurs and on the links between their activities and that of other groups. The overview should address the national context and the agricultural and industrial sector in order to get a rough idea of the major problems, of biotechnological solutions that are feasible and of the prevailing conditions that need to be taken into account.

* For an elaborate discussion on the 'interactive bottom-up approach' I refer to the book "Appropriate biotechnology in small-scale agriculture: how to reorient research and development", J.F.G. Bunders and J.E.W. Broerse (eds.), CAB International, Wallingford, UK, 1991.

The often incoherent information will need to be processed. This may be quite difficult. There will be much information on why things do not work and why they never will without major structural changes. Usually there is no consensus on what solutions are feasible. For the members of the formal team it is difficult to weigh the different problems and solutions against each other. To deal with these problems, an informal team of people, committed to the improvement of small-scale agriculture and industries should be established. The informal team consists of representatives of relevant institutions for agricultural and industrial development. Potential members will already have been identified during interviews. In this team, the information gathered so far can be discussed on the basis of draft reports written by the formal team. Discussions should focus on opportunities and on how to deal with constraints rather than trying to define those constraints more precisely.

The huge amount of information available must result in an integrated view on the role biotechnology could play in rural development. At one extreme, it will be concluded that biotechnological projects for small-scale producers simply cannot be justified. This would imply that virtually none of the conditions necessary to stimulate SSEs and to introduce biotechnological innovations pertain or could be met within the foreseeable future. Three basic conditions can be mentioned for the stimulation of SSEs: (i) there must be a market for goods produced by SSEs, (ii) there must be some tradition of small-scale artisan or household production and marketing, and (iii) there should be government recognition of SSEs' potential role in development, so that effective policy measures will at least be considered (Teszler, 1989b). No attempt should be made to grow small-scale industry where nothing else will grow, because it probably won't either. In other cases, however, stimulation of SSEs seems possible and some biotechnological innovations will be found to be 'enabling'. The remaining challenge is to use the wealth of information gathered to establish and justify a prioritization of the problem areas to be dealt with by biotechnological innovations.

2. *Public debate*

The result of the first phase is a reasonably specified and coherent view on the role of biotechnology in serving the small-scale producers in an appropriate and feasible way. However, the results of these activities need to be reviewed and discussed not in the least by those interviewed. They must have the opportunity to criticize the analysis. After all, only those in the formal and informal teams will have had an overview of the full range of opportunities and constraints. It would be misleading to present the integrated results as a consensus document when those who have contributed do not get the opportunity to react. In any case, iteration of analysis may engender new contributions. The fact that many people have been involved in (parts of) the process does not ensure that all opportunities and problems have been identified. Furthermore, a wider discussion is a way of legitimizing the findings of the preparatory phase.

In a public debate, the output of the preparatory phase is discussed widely and openly in order to gain support and to anticipate negative side-effects, constraints and synergies relevant in further developing the innovation. It may lead to the rejection of (part of) the ideas, or to a change of priorities and adaptation of the proposals. Ways of achieving a receptive environment for the effective implementation of the innovation will be discussed. Given that small-scale producers are usually not capable of attracting attention to their situation, a public debate will contribute to the visibility of their needs and problems and arouse public and political support. This will enhance implementation.

3. *Institutionalization*

On the basis of the proposals prepared during the two previous phases, decisions can be made in different organizations. Producers' and women's organizations, governments of developing and developed countries, international donor organizations, universities, corporations and others may feel that they would like to follow up on the ideas presented. They can prepare new projects, initiate programme studies, adjust existing institutional frameworks and/or establish new ones. There are, however, two real dangers during this phase. Firstly, once a momentum has been created, the ideas and plans become vulnerable to forces which pull them away from their original design. The different individuals and organizations involved may have 'hidden agendas' and only use the general support for the ideas to realize their own interests (Bunders and Broerse, 1991; Honadle and Klaus, 1979). A second danger is that the ideas of the report are not picked up. In the same way that 'trickle-down' to small-scale producers does not occur naturally, the process of 'trickle-up' to implementing organizations needs specific stimulation. These dangers necessitate subsequent activities of (a part of) the informal team. Its members should stimulate and initiate follow-up activities to ensure that appropriate projects, programmes and institutions are created, and they should monitor the developments.

The design of projects requires specific attention. The information collected in the previous two phases will not be specific enough to allow for a thorough design of project proposals and does not guarantee the appropriateness of the proposed biotechnological innovation in a specific region. Therefore, criteria for formulation and assessment of project proposals are necessary. Clear and well-thought out criteria will improve the identification and planning of the activities, making it more likely that the project results will be produced on schedule and be of the kind, magnitude and quality specified. This will, in turn, increase the probability that the project and development objectives will be attained. Having formulation and assessment criteria (a checklist against which proposals can be measured) is a necessary condition. They will, however, not guarantee a project's success since one can never be sure that the original project design or plan will work over time, particularly in a dynamic context.

We are, therefore, developing a set of criteria (presently only in guideline form) which require that proposals demonstrate that certain aspects of the project have been specifically considered. At the same time, they leave room for flexibility in the way these aspects are dealt with. More than in quantitative statements, we are interested in qualitative statements based on the best available information. The guidelines have been developed on the basis of evaluations of earlier innovations in developing countries and recent developments in biotechnology. The guidelines we propose for formulation and assessment of project proposals on biotechnology for small-scale producers in developing countries are as follows. A proposal should:

1. *Demonstrate how the end-user needs have been identified, how they have been involved during the design of the project and how they will be volved during its execution.* Evidence should be provided that a genuine need of the target group is identified. Proposers need to ensure that the research process maintains close and on-going links with, and is ultimately accountable to, its consumers/clients (market- rather than technology-led development).

2. *Outline the anticipated economic, social, environmental and cultural impacts.* Among the considerations should be:

- The *type and scale of the problem* addressed. A thorough description should be given of the problem addressed by the proposed innovation.
- The *input changes* implied by the innovation. The most appropriate biotechnological innovations will usually be those which neither require significant inputs nor significant changes in inputs.
- The *output characteristics* of the innovation. The output of the innovation should meet the demands of the target group.
- The *income-generating effects.* In order to realize income, the outputs of the innovation have to be profitably marketed. Knowledge of the market-supply and demand and the numerous factors affecting prices needs to be acquired, and the market for a new product must be tested.
- The *effect on social and economic relations.* A proposal should consider the scope of the innovation for influencing the broader social and economic circumstances of the people involved. Among other things, attention should be paid here to the labour-using characteristics of the innovation.
- The *effect on the robustness* of the production system. One needs to ensure that the robustness of the production system (stability of the output and sustainability of the production system) is not negatively affected by the innovation.

3. *Demonstrate how the generation of the proposed biotechnological innovation fits into existing rural development policy* and that it has the necessary formal and informal support. The proposers must be convinced that the innovation will at least be broadly welcomed by various different groups who will be affected by it.

4. *Outline the institutional mechanisms* envisaged both for the research and development process itself and for the dissemination of the innovation to the target group. There must be effective mechanisms to translate R&D into marketable products and to disseminate the innovation to the target group. It is important to consider not only whether there are mechanisms for reaching the target group, but also what support services are needed (such as credit schemes, training facilities, sources of energy and assistance with quality control), if these services are already available and function properly or need to be established or improved.

5. *Indicate whether synergy (or antagonism) with other technological, political or economic measures exist* and how it can be used (or circumvented). Any project should try to make the best use of the possibility of synergies since it will facilitate its preparation/implementation.

6. *Demonstrate that the proposed biotechnological innovation is both technically feasible and safe.* One needs to ensure that the innovation will perform properly not only in the laboratory or research station, but also under prevailing conditions and

management procedures of the target group. Ultimately, the end user is the final arbiter of 'technical success'.
7. *Show that the biotechnological innovation has a comparative advantage over other options*. The proposers involved need to demonstrate an awareness of alternative approaches (competition analyses) and to show that the proposed project is the best way of obtaining the stated objective.
8. *Pay explicit attention to technology transfer and the building of indigenous research capacity* to enhance the self-reliance of developing countries. The mechanisms of aspects such as training and intellectual property issues should be described.
9. *Give details of the organization and management of the project*. The project must be managed in such a way that complex multidisciplinary data can be processed and the right decisions made. Feedback mechanisms which refer to specified achievements must be instituted to guide the project.
10. *Stipulate realistic time-scales for completion of the project or achievement of its objectives* so that a project does not fail simply through exhaustion of funds. A good way of ensuring that the recurrent costs of a technological development project are met, is to build in a self-financing capability right from the start.

Technological, economic, and social viability are all part of successful biotechnological practices and they must all be taken into account since the failure of one means the failure of the whole. Although this may all seem very logical, technological projects are hardly ever designed in this way.

7. Implications for national and international research institutes

The international research community, such as the IARCs (International Agricultural Research Centres), ICGEB (International Centre for Genetic Engineering and Biotechnology) and IRSIs (Industrial Research and Services Insitutes; see box) as well as national research systems in developing countries have to play a decisive role in ensuring that biotechnological research for small-scale producers takes place. They are already involved with applications of biotechnology in addressing concerns of poor countries and poor people. International development research centres are in both a central strategic position and an intermediary position between the major research centres in the developed world on one hand and the research needs in the different African countries on the other hand. However, the approach we advocate for technology development is not currently practiced by national and international research centres. Many research centres face problems in the following areas (UNIDO, 1979; Veenstra, 1991):

- limited knowledge of local conditions and needs;
- little or no participation of end users in priority setting and R&D activities;
- insufficient attention for traditional knowledge and technologies;
- insufficient dissemination of technological information; and
- insufficient 'follow-up' activities and long-term commitment to the end users.

Industrial Research and Services Institutes

The Industrial Research and Services Institutes (IRSIs) have been established by UNIDO in the mid 1960s. IRSIs' goal is to stimulate and influence industrial development in developing countries. In the beginning, IRSIs focussed at middle and large-scale industries, but later they increasingly stimulated the SSE sector. IRSIs function as mediators between the government on the one hand, and UNIDO and the industrial sector on the other. IRSIs give direct and institutional support with the objectives (i) to improve technological management and marketing skills of entrepreneurs, and (ii) to improve and adapt production processes, techniques and products. To reach these objectives, IRSIs perform the following activities:

- supporting services: testing and analysis of products, pre-investment studies, technological information collection and distribution, standards, quality control, need assessment;
- extension services: trouble shooting, process improvement and rationalization, industrial engineering, quality improvement;
- R&D: product improvement, process development and improvement, materials R&D, application R&D; and
- training: managerial and technological skills.

(UNIDO, 1979)

The development research community will, besides ensuring that it has high-grade scientific manpower and attracts sufficient funds for its operational needs, have to focus its research more on a specific target group and its needs and problems, and above all, have to foster an integrated approach to needs assessment, research, development and dissemination of the results. These are the necessary conditions for using new technologies for the benefit of the rural poor of Africa.

When confronted with a participatory, bottom-up approach which includes a wide-ranging list of considerations which go far beyond the ground with which they are familiar, many scientists may feel dismayed. Some of the conditions they may view as obstructionist because they deflate their good intentions or irrelevant because they are not technologically based. Many proposing organizations will simply not have all the skills and resources necessary to meet or even address the guidelines. It should, however, not be assumed that we are suggesting that would-be proposers need to become development experts overnight. They do need, however, to become flexible and inventive in gathering relevant information. They may need to learn, at least, how to communicate with those involved in development. Proposing organizations could, for example, consider collaborating in a 'joint venture' with one or more groups with complementary skills and resources necessary to achieve specific objectives. Such an arrangement could help in (i) the identification of a genuine need of a target group, (ii) the implementation of an applied/adaptive research stage at local level, and (iii) the widespread extension of the finished 'product'. Jointly, these groups could submit proposals which were far more comprehensive (going beyond mere technology), far more realistic and far more likely to attract development funding.

International research centres (IRCs) should be 'research-for-development' centres in the true sense of the word: that is, the centres should be oriented to contribute to an effective development of client groups such as small-scale producers and their production systems, aspects of developing countries which have all too often been ignored. If IRCs are going to apply the 'interactive bottom-up approach' this simultaneously creates both exciting opportunities and dilemmas. The principal opportunity presented by is that the inputs of different groups and activities involved in technology development can be planned and coordinated effectively. But it is the dilemmas which arise with the integrated process which should be of concern since these could be the rocks on which the adventure might founder. We will review the main dilemmas briefly and make some recommendations on structure and organization.

Focus on academic research or on development

IRCs aim to be nerve-centres for strategic research on topics that are important for the development of Africa. This aim raises the fundamental question of whether frontier science and research for development, application, conversion and adaptation of technologies are compatible. The only criterion for excellence is the relevance of its findings for the target group. Yet scientists will feel pressure to pursue science which is challenging for its own sake. In order to retain good scientists, a balance between the two extremes will have to be struck.

In striking such a balance, should the agricultural scientists who, after all, know their own research area best, be free to choose their own research topics? Is such decentralized research planning just as effective in promoting development? Not according to Hobbs (1990). He analyzed decentralized national agricultural research systems and found that extensive decentralization makes it virtually impossible to formulate a coherent overall program. Decentralization and scientific freedom must therefore be constrained both to ensure that the work has a development perspective and to facilitate regional and local integration (see later). Within the constraints, the scientists should enjoy as much freedom as possible so that they retain enthusiasm, creativity and contacts with the wider scientific community.

Thus, although the scientists' activities will be expected to correspond to accepted scientific standards, scientific or academic progress will not be the only relevant measures to be considered. Research has to be the handmaiden of development. It will be important to develop a yardstick by which the value of science to development can be measured.

The same philosophy can be used to determine the balance that needs to be struck between the IRCs' activities in assessment, research, development in dissemination. Excellence must be judged holistically: excellence in just one aspect (need assessment and identification of research themes, or research itself, or dissemination) does not ensure excellence overall. Irrespective of the value of separate elements in a specific project, it is their integration that is most important. It is the responsibility of IRCs to bring together all aspects of the research and development process: to collate available information, to bring that information together in joint-programmes, to minimize duplication, and to use and to strengthen existing capabilities. Such attention to local conditions and opportunities and applicability of the results must become second nature in IRCs.

Fundamental research - applied research

In conventional organizations, fundamental research and applied research are separated structurally; different people, different organizations, different buildings. In biotechnological research, however, the two are extremes on a continuum. Again, the IRCs, both in their programme and in their structure, will have to strike a balance between the two, to create synergies and minimize disadvantages.

Application-oriented attitudes should be strong in need assessment and extension. Fundamental approaches, on the other hand, are needed in research and problem solving. All these tasks fall within the remit of many IRCs and, if managed properly, the strengths of both approaches should be complementary. What is needed is an integrated approach in which cooperation between technical and social scientists is based on a mutual of individual contributions.

Local/regional focus - international focus

Another dilemma arises in deciding where the focus on the target group should fall. With the broad 'research for development' philosophy, the disadvantage is that Africa is too broad a clientele to address. The target group has to be more precisely defined so that IRCs can understand and be responsive to its needs. Ideally, extensive assessment of the needs of all groups in African countries and subsequent prioritization could enable choices to be made. However, that would be prohibitively expensive and time-consuming. Moreover, it would be extremely unrealistic to hold one institute responsible for reaching all end-users. Therefore, we suggest a somewhat pragmatic approach.

The need assessment and prioritization processes should be conducted within just two 'model countries' which are representative of various agro-ecological zones and socio-economic categories of Africa: e.g. the rain forest, the transitional savannah, or the sahel. Within the two countries, the effort should focus on the rural poor. Production of agricultural inputs, farming, processing and consumption are intimately linked and identifying the constraining influence on development of each of these components would provide a major input in helping to define and structure the R&D programme of IRCs. For instance, it would determine whether it will be more effective for the research programme to concentrate on increasing production at the farm level, on developing or improving post-harvest and processing techniques, on improving nutritional value, or on other areas. IRCs must make an inventory of what has already been performed, of what is already known and of where this expertise is located. The findings can be widely discussed in seminars, workshops to be organized by IRCs. Only then can IRCs acquire their major focus and define their programme. This approach has already been used in identifying and prioritizing research and development in the International Institute for Tropical Agriculture.

Although IRCs must focus on a specific target group, the rural poor, this does not mean that another extremely important group -governments and policy-makers- can be ignored. The commitment and support of governments has to be won. Without it, IRCs in the long run might encounter political problems, regardless of their success judged from the perspective of the rural poor. IRCs will have to interface with existing policies (e.g. food policy, economic planning) while defining their own national niche and stressing to the government the value of its information and expertise.

Having focussed on just two countries, IRCs can then look to verify whether key factors which emerged from the assessment phase in the two countries hold valid in some or all of the other African countries. There might then be a tendency to focus research on those aspects that are the most widely applicable. Implementation of the research programme would, however, still focus on the two model countries.

Linkage with the national research systems

A fundamental factor is the relationship of the IRCs with national research systems. In order for research to be best able to take the necessary steps towards integrated development, applied/adaptive research and technologies will have to be transferred to national research systems. IRCs could render important assistance to African countries by delivering the products (physical products and know-how) of its research and development, by acting as a clearing-house or reference centre or, even more importantly, by providing training. The training provision would not only concern high-level biotechnology but also, among others, the skills required for need assessment, prioritization of research and adjustment of solutions to local conditions.

IRCs should also provide training for policy-makers at the national and regional level. For most of them, the threats and opportunities of both modern and traditional biotechnology for their countries will be unknown. Additionally, regulatory officers will be expected to design and implement legislation specifically geared towards biotechnological research or the application of its results, subjects with which most policy-makers will be unfamiliar. Thus, IRCs can play an important supportive role and, at the same time, build a constituency.

The most important innovation at IRCs, will not be any of their specific findings, but the general philosophy and the nature of the results. The centres are themselves, therefore, a model and should be the subject of training activities. Training researchers and others in spreading and applying the 'research for development' philosophy will, perhaps, be the most effective instrument that the IRCs could provide to alleviate poverty.

References

Broerse, J.E.W. (1990) Biotechnology: a challenge or a threat? In: *Research and Development Cooperation: The role of the Netherlands*, C. Schweigman and U.T. Bosma (eds). Royal Tropical Institute, Amsterdam, The Netherlands, 123-140.

Bunders, J.F.G. and Broerse, J.E.W. (eds) (1991) *Appropriate Biotechnology in Small-scale Agriculture: How to reorient research and development*. CAB International, Wallingford, UK.

Clark, N. and C. Juma (1991) *Biotechnology for sustainable development; policy options for developing countries*. ACTS Press, Nairobi.

DGIS (1989) Biotechnology and Development Cooperation: Inventory of the biotechnology policy and activities of a number of Donor Countries and Organizations, UN Agencies, Development Banks, and CGIAR. Report of the Netherlands Directorate General for International Cooperation.

Doele, H.W., Olguin, E.J. and Prasertsan, P. (1987) Fermentation technology and its impact on culture and society. In: *Microbial technology in the developing world*, E.J. Da Silva, Y.R. Dommergues, E.J. Nyns and C. Ratledge (eds). Oxford University Press, UK, 209-225.

Ewell, P. (1989) Linkages between on-farm research and extension in nine countries. OFCOR Comparative Study no. 4, International Service for National Agricultural Research, The Hague, The Netherlands.

Freeman, C. (1989) New technology and catching up. *The European Journal of Development Research*, vol. 1, number 1, 85-100.

Hobbs, S. (1990) Problems and solutions for 'decentralizing' national agricultural research systems. Working paper no.36, International Service for National Agricultural Research (ISNAR), The Hague, The Netherlands.

Honadle, G. and Klaus, R. (1979) International development adminsitration: Implementation analysis for development projects. New York, USA.

ILO (1980) Rural Technology Centres: their role in technological self-reliance of developing countries. International Labour Organisation, Geneva.

Joffe, S. and Greeley, M. (1990) New plant biotechnologies and rural poverty in the Third World Paper prepared for Appropriate Technology International, Washington D.C., USA.

Junne, G.C.A. (1987) Bottlenecks in the diffusion of biotechnology from the research system into developing countries' agriculture. In: *Proc. 4th European Congress on Biotechnology*, 4, O.M. Neyssel, R.R. van der Meer and K.Ch.A.M. Luyben (eds). Elsevier, Amsterdam, The Netherlands, 449-458.

Kaplinsky, R. (1989) 'Technological Revolution' and the International Division of Labour in manufacturing: a place for the Third World? *The European Journal of Development Research*, vol. 1, number 1, 5-38.

Kenney, M. (1986) *Biotechnology: the university-industrial complex*. Yale University Press, New Haven, USA.

Kenney, M. and Buttel, F. (1985) Prospects and dilemmas for Third World development. *Development and Change*, vol. 16, 61-91.

Lewis, C.W. (1987) Biotechnological practices in integrated rural development. In: *Microbial technology in the developing world*, E.J. Da Silva, Y.R. Dommergues, E.J. Nyns and C. Ratledge (eds.). Oxford University Press, UK, 87-120.

O'Donnell, M. and Hyman, E.L. (1987) Commercial analysis: A tool to assist small enterprises. In: Report of Appropriate Technology International 1984-1987, ATI, Washington, USA, 15-17.

Persley, G.J. (1990) *Beyond Mendel's Garden: biotechnology in the service of world agriculture*. CAB International, Wallingford, UK.

Ranis, G. (1990) Rural linkages and choice of technology. In: *The other policy: the influence of policies on technology choice and small enterprise development*, F. Stewart, H. Thomas, T. de Wilde (eds.). IT Publications, Washington, 1990.

Richards, R. (1985) *Indigenous Agricultural Revolution: ecology and food production in West-Africa*. Hutchinson, London, 1985.

Röling, N. (1991) Institutional knowledge systems and farmers' knowledge: Lessons for technology development. In: *Savoirs paysans et développement*, G. Dupré (ed). Karthala - Orstom, Paris, 489-517.

RSIE (1988) Development of rural small industrial enterprise - lessons from experience. UNDP, Government of the Netherlands, ILO, UNIDO, Vienna.

Sasson, A. (1988) Biotechnologies and development. UNESCO, CTA, Paris.

Teszler, R. (1989a) Development cooperation and promotion of small and micro enterprises in developing countries. In: *Small enterprises, new approaches*, A. Gosses, K. Molenaar, Q. Sluijs and R. Teszler (eds.). Ministry of Foreign Affairs, Directorate General International Cooperation, The Hague, The Netherlands, 21-35.

Teszler, R. (1989b) What are small enterprises? In: *Small enterprises, new approaches*, A. Gosses, K. Molenaar, Q. Sluijs and R. Teszler (eds.). Ministry of Foreign Affairs, Directorate General International Cooperation, The Hague, The Netherlands, 11-20.

Teszler, R. and Molenaar, K. (1989) In search of new approaches; major areas of attention. In: *Small enterprises, new approaches*, A. Gosses, K. Molenaar, Q. Sluijs and R. Teszler (eds.). Ministry of Foreign Affairs, Directorate General International Cooperation, The Hague, The Netherlands, 37-45.

Vreeman, S.J. (1991) Stimulation of small-scale industries in developing countries: the role of Industrial Research and Services Institutes. Thesis, University of Twente, Enschede, The Netherlands (only available in Dutch).

Wilde, T. de (1987) Small enterprise development: changing paradigms and contexts. In: Report of Appropriate Technology International 1984-1987, ATI, Washington, USA, 10-14.

Wilde, T. de (1988) Removing barriers to spark dynamic small-scale enterprise development. In: Report of Appropriate Technology International 1987, ATI, Washington, USA, 11-15.

World Bank (1990) World development report 1990: Poverty. Oxfort University Press.