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Agricultural Biotechnology in Developing Countries: Nature and 'Code' in Meeting the Needs of Resource Poor

P S Janaki Krishna* and G Pakki Reddy**

Abstract: Agriculture forms the backbone of economies in most of the developing countries. Hence this sector has an important role in meeting the needs of poor. In agricultural development biotechnology is viewed as one of the powerful tools. In the history of agriculture known to mankind agricultural biotechnology is perhaps one of the most rapidly growing technologies. However, while observing the present nature of biotechnological developments, the socio-technical issues in meeting the needs of resource poor have always been argued. While addressing these issues several national and international programmes are trying to harness the power of this technology for the benefit of resource poor. This paper is based on the experience of a Dutch funded Programme entitled "Andhra Pradesh Netherlands Biotechnology Programme for Dryland Agriculture (APNLBP)" that is in operation for about a decade in one of the Federal States of India. The Programme has made earnest efforts in tailoring the biotechnologies in order to meet the needs of resource poor farmers in two dryland districts of Andhra Pradesh. In this paper the first section deals with the nature and 'code' of biotechnology development wherein the need for dovetailing the social dimensions in technology development are discussed. The second section highlights on rationale for application of biotechnology in developing countries while section three details with the experiences of APNLBP in developing appropriate biotechnologies using an 'interactive bottom up' approach that provides a new research paradigm.

Nature and 'Code' of Biotechnology Development in Agriculture

Biotechnology is traditionally defined as the use of living organism in producing a product or process. The 'Convention on Biological Diversity' (1992) defines biotechnology as "*any technological application that uses biological systems, living organisms or derivatives thereof, to make*

* Consultant, Institute of Public Enterprise, Hyderabad 500 007. Email: jankrisp@yahoo.com & hyd2_btuipe@sancharnet.in.
** Professor and Coordinator, Institute of Public Enterprise, Hyderabad 500 007. Email: gpakkireddy@hotmail.com

or modify products or processes for specific use". The 'Cartagena Protocol on Biosafety' (2000) defines modern biotechnology as "*the application of 'in vitro' nucleic acid techniques, including recombinant deoxyribo nucleic acid (DNA) and direct injection of nucleic acid into cells or organelles or fusion of cells beyond the taxonomic family, that overcome natural physiological reproductive or recombination barriers and that are not techniques used in traditional breeding and selection*". These definitions suggest that biotechnology is referred to a broad area of bioscience. Therefore, the term 'biotechnology' is now understood as use of knowledge of biological systems to produce goods and services. Throughout this manuscript the term biotechnology is used in this broader context.

Biotechnology is said to have a high potential to help alleviating some of human sufferings. However, if we look at the nature of modern biotechnologies that have been developed until now, it can be observed that there is a strong tendency towards industrialization. For this reason it has been bitterly criticized both for scientific and non-scientific considerations. For decades, the debate on biotechnology is in a pro contra stalemate. It is often criticized that biotechnology is a technology that has been shaped by a narrow range of private interests – interests that are incompatible with the demands of an ecologically sound and socially just agriculture. In the last decade or so, the transnational corporations have emerged as a major source of biotechnology products. This trend has further compounded the concerns among developing countries as reports about biopiracy become galore.[1] Also, it's application by the resource poor farmers in developing countries is not advantageous primarily because it is not affordable and secondly, it does not address their immediate problems. For example, the widely grown herbicide tolerance developed through transgenic technology in crops in developed countries is not a priority problem in developing countries where the land holdings are comparatively small and weeding can be done by manual labour in a cost effective manner. Arguably this technology in this case might substitute the labour force.

Moreover, increasing attention is being placed on the 'social acceptability' of the introduction of biotechnology into agriculture sector, which is the major source for food production. In Europe, this is a crucial factor impending the growth of biotechnology. In fact, attempts have been made to extend information to different groups within the society in order to solve the 'acceptability' problem of biotechnology. Here, one may understand that each technology including biotechnology is developed within a specific context. Besides technical dimensions, each technology also has social dimensions, such as (i) the context in which the technology is developed, (ii) the social relations that are reflected in the technological development, and (iii) specific aims for which the technology is applied. Likewise, biotechnology is not only a cluster of techniques but also has specific socioeconomic aims. It is also clear that certain biotechnological developments with a specific socioeconomic context will be of relevance to some parties while for other social groups it may not be acceptable. Hence, the 'non-acceptability' of' 'some' biotechnological developments by 'some' cannot be labeled as outrageous or alarming behaviour, but must be taken seriously and understood as a criticism of specific socio economic content or 'code' of biotechnological developments. The demand for a negotiating process on a socially acceptable 'code' in the development and application of biotechnology in the agriculture sector comes from the awareness that biotechnology promotes a specific new form of integration of the agriculture sector within the agro-industrial chain of production.[2] To allow for practical and social control over technology, the existing separation between designers and users of technology should be dealt with and technology development should be related to clear societal targets and aims.[3]

This denotes that biotechnology products will radically change the position and practice of farming. Therefore, it will become impracticable to neglect or mask the socioeconomic dimensions of the new biotechnological products. The heterogeneity of the agricultural sector and the different perspectives of these sustainable farming styles might become the new context in which the biotechnology development has to be re(designed). It means that there should be willingness from the technology designers and developers alike to participate in the discussion process on the socio-economic and technical contents (codes) of biotechnology. Just like any other technology, the powerful (bio) technologies developed thus far in the developed nations are equipped with a certain guidelines of usage that limits the area of application of the technology. This guideline can be called as 'code'.[4] However, recognition and analysis of the implicit guidelines in technologies make it possible to evaluate these technologies and find out which people benefit (or not) from them. It also necessitates for a more conscious design process including a specific set of social and technical dimensions that were the code of local agrarian practice, which considers local knowledge, local practice and social structures. In other words, the social and technical dimensions or code of a biotechnology are more likely to fit together with the social and technical dimensions needed for the local agrarian situations, if the biotechnology is developed interestingly with the farmers. The specific social dimensions include the feasibility, acceptance, adaptability and affordability of new technology by the farming community in general and resource poor farmers in particular. The technical dimensions in case of biotechnology include the complexity of the technology, multidisciplinary nature of the technology, and intellectual property rights, risk management strategies, regulatory mechanisms regarding biosafety, etc. If the benefits of the technology are to be reached to resource poor these social and technical aspects of biotechnology have to be kept in mind in determining the code of technology development.

Thus, the '*concept of code'* makes it clear that every single technology including biotechnology and every technological innovation is a means to accomplish certain goal but at the same time it is also something that influences reality. By this we can also understand that every research programme/technology/product has a 'code'. Though the nature of technology has influence on the 'code', the designers of technologies can prescribe it depending on their ultimate goal. Although the technology design may be strongly determined by the dominant social relations, it is not inevitable that this occurs. Guido Ruivenkamp (2004) argues that when the cultural horizon of society changes about what is acceptable, the design of the machinery may also be modified, illustrating that technology development is not inevitable related to the powerful but that the design is negotiable and depends on the outcome of the struggle about specific social relations.[5] The specific code of a technology is thus not only a means to influence, but also a reflection of social interest and social and political processes of balance that can be found in society. Nevertheless, one can still notice that the social 'codes' in technology development as well as the possibility of intervening in the formulation of the social codes of a new technology are still neglected.

However, the implicit guidelines/code of technology can be recognized by asking the questions such as: which people benefit and which not? In this regard, if we look at the players in biotechnology field, the dominance of private sector in agricultural biotechnology research and commercialization has raised number of issues relating to the preceding pertinent question. In general, the manufacturers of biotechnological or any products tend to focus more on profit maximization from their products. They perceive small farmers as unattractive groups to invest in. Especially, big industrial entities are mainly interested in cheap bulk products, which can only be provided by large-scale farmers. Furthermore, small-scale farming is usually characterized by its complexity, its divergence in farming styles and its priority to minimize the risk. This specific agricultural background is called *complex, diverse and risk prone* (CDR) agriculture.[6] Hence the concern for small farmers was expressed primarily from the risk that technological advancement (like biotechnology) may bypass them or worsen and result in adverse impact on them from not only direct impact of the technological change but also indirectly due to economic, social and environmental changes that follow a technological change.[7] Since it is argued that resource poor farmers are hard to reach with modern biotechnologies developed in "developed countries", it was often stressed that specific programmes would be required to reach the resource poor in the developing world.[8] The following statement from Norman Borlaug (2004) reiterate the fact that developments in biotechnology should be understood in much broader perspective than just science.

"The world has the technology – already available or well advanced in the research pipeline – to feed on a sustainable basis a population of 10 billion people. However, access to such technology is not assured. The range of potential barriers includes issues relating to intellectual property rights, technology acceptance by civil society and governments and financial and educational barriers that keep poor farmers marginalized and unable to adopt the new technology"

Thus, having noticed the influence of 'code' on the nature of research that is being conducted it would be worthwhile to observe the rationale for applications of biotechnology in developing countries wherein the majority of the resource poor farmers live in.

Rationale for Applications of Biotechnology in Developing Countries

It is being stated quite often that after the information and communication revolution, the mankind is witnessing yet another revolution, i.e. biorevolution. The advancements in life sciences have made it possible to introduce a number of innovative technologies, which have a profound influence on the nature of products and processes. Biotechnologies emerging from different branches of life sciences have already made deep in roads into health sector and continuing to surge ahead in agriculture and a number of other sectors like animal stock breeding, industrial processing, food processing, waste treatment, etc. The applications of biotechnologies in agriculture are said to have far reaching consequences particularly in developing countries in terms of food security and nutritional improvement. Estimations by international agencies like Food and Agriculture Organization (FAO) and United Nations Development Programme (UNDP) suggest that biotechnologies offer some solutions to the problems of hunger and poverty, particularly in developing countries where more than 800 million people go hungry every day. A number of industrialized nations share this view and even support the developing countries under bilateral cooperation to augment their resources to undertake research and develop biotechnologies. This is in addition to huge investments they made in biotechnological research through Consultative Group on International Agricultural Research (CGIAR) institutions. Recognizing the potential of this new technology, multinational companies, having their roots in industrialized nations, too have committed significant investments. The impacts of such investments seem to be trickling down with ever-increasing areas under genetically modified crops world over which has already crossed 81 million hectares (James, 2004). A significant feature of this phenomenon is that such trends are predominant in Western countries like the USA, Canada, Argentina and a few European countries. But what is striking is that some of the developing countries like China, South Africa, Brazil and India too began adopting these technologies and registered very high growth rates. From this, it is evident that while the pro-contra debate on the relevance of biotechnologies continues, their impact is already seen at the market place. Thus, biotechnology impact on agriculture is expanding to many countries though the extent of this impact differs from developed countries compared to developing countries. The successful application of agriculture biotechnology in industrialized countries could be of value in developing countries.

However, the dominance of private sector in agricultural biotechnology research and commercialization has raised a number of concerns about who will benefit from biotechnology. The available empirical evidence on impact of transgenic crop research in developing countries shows that resource poor farmers can benefit from GM crops if the crops address their needs and if they have access.[9] At the global level, a number of international and regional co-operations are attempting to place biotechnology into proper perspective. However, development oriented biotechnology, which spans a research spectrum from basic, goal-oriented science to applied field-tested technologies, raises new issues with regard to implementation. Careful consideration of these aspects led to biotechnology based collaborative programmes and these advanced research networks are having a positive impact upon research in developing countries.[10] Recognizing the potential of these technologies the governments worldwide have taken steps to harness them for their development. Several Asian countries have built impressive institutional infrastructure and capability in different areas of applications.[11]

There are three important features in biotechnology. Firstly biotechnology is heavily driven and developed by private investment; secondly it is knowledge-based industry; and thirdly it has risks associated with it, which may extend to unknown boundaries. Developing appropriate policies to explore the positive potential of the technology has to take into account the above features. Another point that needs to be mentioned from point of view of the industry is that biotechnology industry is generally divided into upstream (those which make inventions) and downstream (those that commercialize the invention). Each has further division based on specialized application area. The upstream firms are established in clusters at centres of excellence where there is knowledge and innovation, whereas the downstream firms are not in cluster, but operate internationally wherever there is commercial market for their service and profit. Therefore, biotechnology development and transfer to developing countries need to take into account these historical features of biotechnology.[12]

Hitherto, the diffusion of technology in many developing countries is not as strong as developed countries. While there are many differences between developed and developing countries, there are some similarities too. Building upon these commonalities, it is possible to utilize the biotechnology that might have been designed for use elsewhere. For example a Hepatitis B vaccine costs around US $ 15, whereas using the same technology to produce a genetically engineered plant vaccine in a plant such as tomato or bananas can provide the same immunity while costing less than one cent.[13] However, to utilize this technology efforts should be made for diffusion of the technology and its applications to local conditions. Also, to realize the biotechnology potential in reducing poverty, the technology has to be directed towards the poor. The UNDP Report on Human Development (2001) calls for identification of key health and agricultural challenges as the focus of biotechnology application. In addition to that, technology flow and information dissemination mechanisms should be feasible and a risk management mechanism should be in place to ensure sustainability. Therefore, tailoring biotechnology in agriculture in developing countries has been considered as the need of the hour.[14]

While considering the applications of biotechnology in developing countries, one should not be passionate in dealing with only rDNA technologies whose acceptability is low, gestation period is high and investments are high. The hard core of biotechnology might be genetic engineering. However, the other applications of biotechnology using tissue culture, microbiological applications, molecular markers, diagnostic kits, biomass utilization and livestock improvement are equally important from the point of enhancing the productivity and profitability of farming systems. These technologies not only help the poor but also contribute to the preservation of environment. We may become aware that biotechnology in agriculture is lot more than GM Crops. If we observe the biotech timeline and learn how technology has been used to improve the food we grow or eat it all started in 10,000 B.C. – 9,000 B.C. when people started planting crops rather than relying on hunting and gathering for food. In 6,000 B.C. in Mesopotamia, Sumerians used yeast – a type of fungus to make beer and wine. From then it continued to grow along with the important work on heredity by Austrian Monk Gregor Johann Mendel and development of Russet Burbank potato in early 1900s and discovery that DNA is genetic material and describing its structure by Watson and Crick in 1953. From then there is no stop for applications of biotechnology. Now farmers in 18 countries plant GM crops on 81 million hectares. Though the term biotechnology is defined in much broader sense several national and international programmes unfortunately refer biotechnology to only recombinant DNA (rDNA) technology. In terms of complexity of the technology biotechnology can be categorized into three orders, viz. the lower, middle and high order. The level of complexity dictates the amount of knowledge, expertise, technical, equipment, financial resources and time that are needed for any specific biotechnological applications. Keeping the available resources in view developing countries should give equal emphasis to the lower and middle order of biotechnologies as the higher order of biotechnologies in which case benefits of technology could be reaped in much shorter time.[15] This broad perspective on applications of biotechnology should be kept in mind in harnessing the power of biotechnologies in developing countries.

Thus, keeping the nature and code of biotechnology research and its potential in meeting the needs of resource poor in developing countries the Dutch funded Andhra Pradesh Netherlands Biotechnology Programme has been formulated and implemented in an innovative way, which has been described in the following section.

The Andhra Pradesh Netherlands Biotechnology Programme (APNLBP) - Towards Meeting the Needs of Resource Poor

While there is a guarded criticism about possible risks on human health and environment the hard core opposition to biotechnology seems to be on the nature of ownership of the technology and the vested interests of the proponents of the technology. It is argued that the technologies are supply driven and profit oriented. In most cases, they do not even address the needs of common man in developing societies. Against this backdrop, there are certain attempts to change the course of direction of these promising technologies to face the challenge of providing safe and adequate food in the hunger stricken developing countries that promote a new research 'code' and paradigm. Such initiatives are inspired by liberal donor agencies and local governments in collaboration with civil societies.[16]

In this context, it has been the strong belief of the Dutch public policy since early 1990s that the potential of agricultural biotechnology can redress the problem of food insecurity in developing countries provided these countries are empowered to design their own technologies to suit their local conditions. With this objective in view the Dutch assistance has been made available to India, Colombia, Kenya and Zimbabwe. These Country Programmes are constructed around three elements - the integration of the development aspect in Dutch biotechnology policy; collaboration with four countries, and international coordination and cooperation.[17]

A significant feature of these country Programmes is that they are owned and executed by local steering committees having representatives from multistakeholders. With respect to the Netherlands supported programme, i.e. the Andhra Pradesh Netherlands Biotechnology Programme (APNLBP) two points are worth mentioning. By way of background, the autonomy of the programmes is assured by the existence of multistakeholder steering committees (SCs) and the establishment of SCs composed of researchers and representatives of government and grassroots organizations was an absolute Directorate-General for Development Cooperation (DGIS) requirement to ensure autonomy.[18] This emerged into new research paradigm and organizational structures. Unlike most of the internationally funded research projects, the research agenda in these Programmes is derived from the felt needs of local communities. Thus, the process used is in contrast to the typical 'top down' approach. The research focuses on different crops, resistances and properties than those invested in by the multi national companies (MNCs). Thus, the research forms a counter balance - from the perspective of food security and sustainable farming by small farmers in developing countries - to such threatening developments as the use of terminator genes, the exclusive attention given to herbicide resistance, "biopiracy or gene tourism" and the one-sided representation of interests in the (international) regulation of biosafety and intellectual property. During the last ten years the country Programmes achieved substantial progress, though the degree of achievements vary from country to country. Their major success is in producing a viable model through which it is possible to develop a set of demand driven biotechnologies suitable to resource poor farmers and processors. They have also demonstrated that they enhanced their research capacities in handling techniques of modern biology. They even produced technologies that began impacting the living conditions of rural people.

We herewith elaborate the experience of one of the country programmes – The Andhra Pradesh Netherlands Biotechnology Programme (APNLBP). The substantive phase of the APNL Biotechnology Programme started from 1996 after two years of elaborative preparatory phase.[19] The Programme is being implemented by the Biotechnology Unit (BTU) of Institute of Public Enterprise, Hyderabad, India. The initial duration of the Programme was for a period of six years, which has since been extended upto 2007. The APNLBP is a scientific research programme that aims to improve the status of small scale farmers and processors through the development and application of appropriate biotechnology in the semi arid farming systems of Andhra Pradesh, India. The entire Programme is coordinated through a large number of collaborations and networks with existing institutions that are capable of tailoring biotechnologies and transferring them to the farmer. *Barbara Marcus* in the SCOT (Social Construction of Technology) analysis of the APNL Biotechnology Programme referred the Programme as *'obligatory point of passage'* linking up with Ministry of Foreign Affairs (MOFA), the Netherlands and the relevant social groups. The obligatory point of passage is the 'nodal point' between the local and global network where the interactions between the networks are coordinated. The Programme advocates an 'interactive bottom up (IBU)' approach whose bottom line is 'participation of different stakeholders in the technology development'. This approach has emerged from critiques of biotechnology in both developed and developing countries, due to asymmetry in biotechnology research between developed and developing countries.[20]

The 'IBU' approach followed in APNLBP is developed basically on the principles of participatory technology development.[21] The approach regards the research agenda suggested by the farmer/end-user and facilitates the exchange of information amongst all groups. Technology assessment and prioritization of technological requirements by endusers, in this case farmers, is an important element in this process. During this process farmers and scientists work together with professionals from outside their community (scientists with farmers and *vice versa*) in identifying the needs and generating, testing and applying new techniques. The endusers are involved in the entire process right from problem identification, prioritization of problems, project identification, and technology development to technology adaptation, evaluation and refinement.

Using IBU process, a multi-disciplinary team consisting of natural scientists, social scientists, extension workers, administrators, and NGO representatives participated in the *local need assessment survey*, which led to intensive discussions and deliberations in prioritizing specific areas for intervention in dryland agriculture. The output of the survey resulted in a base document for designing the entire Programme and determining the priority areas in a *priority-setting workshop* wherein various stakeholders participated. The priorities that are arrived at for biotechnological interventions are: (i) *Food grains and pulses, (ii) Oil seeds, (iii) Agro-forestry, tree crops, horticulture and sericulture, and (iv) Animal* *production and health*. Surrounding these priorities, *pre-project formulation workshops* (PPFWs) are conducted for identifying the specific projects for funding. PPFWs are the important component of the programme, which give enough scope for different stakeholders including farmers/ farmer representatives to identify specific problem areas for biotechnological inventions. This process enabled the Programme to identify the projects with clear mandate and goals.

Once the projects are established there is always constant interaction between the farmers, NGOs and scientists - the three crucial players in the technology development and evaluation. Farmers in the targeted areas are well aware of most of the technologies being developed under the Programme. Farmers are regularly exposed to the laboratories and are acquainted with the latest technological developments with a view to demystify the technological complexity in the reverse order scientists are exposed to the field twice in a year during Kharif and Rabi seasons to understand the field realities and relate them to their research work. Field demonstrations are carried out both at the research farms and farmers' fields. In order to facilitate these two-way interactions Programme conducts regular 'participatory technology development' (PTD) workshops and 'farmer exposure visits' wherein enough space is created for a dialogue and discussion. Besides this farmers participate in a number of technology demonstration and evaluation programmes.

Participatory monitoring is another important feature of the Programme. The progress of each project is monitored through a well-established monitoring system. These are based on the *principles of participatory monitoring system* wherein the endusers are also consulted and their viewpoints are considered for further fine-tuning of the projects. In fact, many experts and project partners had highlighted this regular monitoring as a special and beneficial feature of APNLBP.

Thus the IBU process inculcated greater responsibility and commitment from the various stakeholders of the programme in endogenizing the technologies to suit to the resource poor farmers of the local areas. The Programme through its process succeeded in ensuring greater commitment from the scientists towards achieving the identified goals, i.e. reaching the poor with the biotechnologies. It also succeeded in establishing good networks with researchers on one hand and farming community and civil societies on the other. Problems of resource poor farmers received focused attention of the Programme. Following the IBU approach the Programme so far supported 75 projects with a total commitment of 300 million Indian rupees (approx. USD 6.65 million). The projects deal with a range of technologies starting from simple, well-established ones such as vermiculture, biofertilizers, biopesticides, botanical pesticides, biocontrol agents, tissue culture, animal feed and animal vaccines to high-tech biotechnologies such as genetic engineering and functional genomics.

Although the non transgenic (non rDNA technologies) are not considered under modern biotechnologies, the APNLBP as a strategy embarked on refining and developing such technologies whose gestation period is less and capable of offering immediate solutions. Such an approach has become inevitable and acceptable in the context of IBU approach, which raises spontaneous expectations from the enduser. Apart from this, these technologies were found to be easily acceptable, ecofriendly, cost effective and amenable for refinement through knowledge in advanced biology. According to Norman Clark *et al*. (2002) the Programme had both a short and long term perspective in its plans for exploiting biotechnology. In the short term, the use of traditional biotechnology application to achieve tangible results would build credibility and social capital with developmental stakeholders including farming communities. This in turn, would promote the long-term exploitation of new biotechnology applications in a more socially inclusive way.

While focusing on tailoring such middle and lower order biotechnologies with intense participation of farming community, modern biotechnologies dealing with recombinant DNA technologies were also given equal importance. The efforts in this regard include genetic modification of crops for biotic and abiotic stress tolerance. They also include isolation and characterization of novel genes mainly for abiotic stresses. The sustained efforts of the Programme during the last one-decade produced both quantitative and qualitative outputs. In quantitative terms about a dozen technologies such as vermicompost, biofertilizers, biopesticides, botanical pesticides, integrated pest management, tissue culture, diagnostic kits for animal diseases, animal vaccines, animal nutrition improvement, integrated livestock development, shelf life improvement of tomatoes and mushroom cultivation and processing have been developed and used by thousands of farmers in more than hundred villages in two districts of a federal state in India. Because of these technologies cost of cultivation is declining, gainful employment is increasing, yield and income levels are rising. Besides these quantifiable results a number of qualitative changes began to take place, which include: convergence of indigenous knowledge with modern biotechnology, resource mobilization, consciousness about social relevance of technology, local capacity building in biotechnology, availability of quality and reliability of products, formation of a base network consisting of various stakeholders, etc. On the environmental front, because of the use of biological means of pest control biodiversity is increasing and occurrence of natural predators is growing. On the whole there is a feeling of well being among the people in these districts. The encouraging results of the Programme led to formulation of new networks and international collaborations, viz. the *Tailor Made Biotechnology Programme*[22] consisting of network partners in Brazil, Cuba, Ghana, India, Kenya and the Netherlands.

Thus, the unarticulated alternative mode of knowledge production underlying the objectives and practices of APNLBP characterizes the evolution of research areas at the frontier of science and technology. In the course of understanding a problem the researchers go back and forth between the "fundamental and the applied, the theoretical and the practical and the curiosity-oriented and mission-oriented research.[23] Being locally driven and constituted, the alternative mode of knowledge production is sensitive to local contexts and is committed to ensuring user involvement not only in the dissemination of findings but also in defining problems and setting research priorities. It recognizes the existence of multiple knowledge sites and views the scientific practices lodged in universities as just one of many such sites that are brought together in the search for solutions to particular problems. Finally, it warrants a new research paradigm wherein a via media model compared to entirely public or private sector owned research is envisaged. Here, civil societies also play a crucial and equally important role in re (designing) the technologies. Also, quality of research is assessed not only in terms of technical merit but also the usefulness and its relevance to the society. As a consequence the emergent research practices are socially more accountable and responsive (Gibbons *et al,* 1999, P: 5). In a similar way the Programme makes sure that the technologies developed are sustained. One of the serious problems noticed in publicly funded research projects in India is that more often than not the research results remain in the shelves and do not reach the intended enduser, for whatever reason. It is the endeavour of the APNLBP that the research results get translated into technologies and they are affordable and reach larger sections of the society. Sustainability is ensured by way of a number of 'mini-bioproduction units' set up at the grassroot level with clear backward and forward linkages. Also over these ten years Programme is able to influence a large network of scientists and institutions towards working for the resource poor. Thus, the APNLBP has succeeded in producing a new paradigm in knowledge production and application for the benefit of resource poor farmers.

Conclusions and Way Forward

Agricultural biotechnologies are expected to meet the needs of resource poor farmers provided the 'code' of research addresses their needs. Several national and international programmes are working towards harnessing the potential of biotechnology in agriculture. However, in the course of knowledge production and dissemination there exists a gap between developed and developing countries. Within developing countries also the nature and code of biotechnology development raises issues with regard to meeting the needs of resource poor farmers. Thus, the socio technical context (code) of research assumes greater significance in (re) designing the new paradigms in research. The APNLBP provides an example in attempting another research paradigm involving different stakeholders including the civil societies in addressing the problems of resource poor through biotechnologies. This model examined by many researchers was found to be fairly successful in developing 'appropriate biotechnologies' towards meeting some of the needs of resource poor farmers. However, institutionalization of this model is still in its infancy. Liberal donor and humanitarian agencies working for the development of poor have to come forward for supporting this kind of research till the message percolates into mainstream research institutions.

Endnotes

1 Chaturvedi and Rao 2004.
2 Ruivenkamp, 1992.
3 Joost Jongarden 2004.
4 Ploeg, 1991 and Procee 1997.
5 In textile industry because of the changed laws enforcing the removal of child labour the whole machinery is redesigned to suit to the adult labour.
6 Chambers 1991.
7 Sharma, Naresh and Janaki Krishna, 1999.
8 Bunders and Broerse, 1991.
9 Duffy 2001.

[10] Pingali and Raney, 2003.
[11] Pant 2004.
[12] Zakri and Taeb, 2002.
[13] UNDP, 2001.
[14] Pakki Reddy and Janaki Krishna, 2003.
[15] As the research on rDNA technology can attract more funds than the other lower and middle order of biotechnologies the researchers are more attracted to this thereby neglecting the potential of these technologies: The vermicompost, biofertilisers, botanical pesticides are simple and environmental friendly technologies wherein the end products can be reached to the farmers in relatively much shorter time. Also, the modern biological tools can as well be applied in these areas like; identifying efficient strains of microbial agents their serotyping, isolating genes from efficient strains, etc.
[16] Pakki Reddy and Janaki Krishna 2004.
[17] From "Integral Policy Document on Biotechnology" issued by five Ministries of the Government of the Netherlands, September 2003.
[18] From "Modalities of donor initiated research capacity building in the South" in "Comparative study of the impacts of donor initiated programmes on research capacity in the South" 2001 P-80. Pub by Ministry of Foreign Affairs, The Netherlands.
[19] Pakki Reddy *et al.* 1994.
[20] From "Contexts of the programmes investigated" in "Comparative study of the impacts of donor initiated programmes on research capacity in the South" 2001 P: 53. Pub by Ministry of Foreign Affairs, The Netherlands.
[21] Pakki Reddy and Janaki Krishna 2002.
[22] Ruivenkamp, 2003.
[23] Gibbons *et al*. 1999, P:23.

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