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Articulating alternatives: Biotechnology and genomics development within a critical constructivist framework

This paper explores critical and constructivist theories of technology, and discusses the political and ideological nature of (bio)technology development. The importance of a conceptualization of technologies as value-laden 'socio-technical ensembles' is discussed, rather than as value-neutral objects, or tools. These conceptualizations are then used to sketch a continuum of development approaches which extends from their relation to a 'transfer of technology approach', to an 'endogenous technology development approach'. This continuum inspires a rethinking of the possibilities to reconstruct biotechnologies and to tailor them to processes of endogenous development. In doing so, the value of participatory methodologies in coming to a contextualized biotechnology development is re-evaluated.

Keywords: biotechnology, endogenous development , participation, socio-technical ensemble, technical code

1. Introduction: new ways of approaching an old debate

The development of agricultural biotechnologies for less developed countries (LDCs) is a widely debated issue. Many researchers have indicated potential benefits that modern biotechnologies may provide to agriculture, also for resource poor farmers in small scale

agricultural systems. For example, the ability to adjust crops to their natural environment, in terms of resistance to both biotic (pest insects, fungi, viruses) and abiotic stresses (drought, salinity), has been claimed to provide opportunities to reach farmers in marginalized and underdeveloped areas[1].

At the same time a lot of criticism has been voiced regarding the appropriateness of currently existing biotechnologies for resource poor farmers. Critical evaluations of the social impacts of the Green Revolution in the 1960s and 1970s (e.g. Pearse 1980)[2], analyses of the industrial and commercial context in which these technologies have been developed (Kloppenburg 1988, 2004), and analyses of the farming systems in LDCs (Bindraban and Rabbinge 2003) strongly indicate that the current technologies 'on the shelf' are badly attuned to the needs of resource poor farmers. Others indicate that modern biotechnologies may provide advances in terms of production, but will fail to address issues of food security and poverty for rural poor.[3]

This observation is the basis for a critical reflection upon the development of modern biotechnologies. The contradiction between the acclaimed potentialities the technologies have to offer, and the actual situation in which these potentialities are *not* being materialized, leads to questions regarding social or historical elements structuring the development of biotechnologies in certain specific directions, based upon an instrumental conceptualization of technologies as solution to social needs.

Acknowledging the controversies over biotechnologies in a development context, this paper is part of a larger research effort which is concerned with processes of tailoring modern biotechnologies and genomics for a very specific context and target group, namely resource poor farmers in developing countries[4]. Instead of engaging in an unfruitful and polarized pro-contra debate over modern biotechnologies, the project sets out to investigate to what extent a

[1] E.g. Prem Bindraban at ICAD conference, Wageningen, The Netherlands, October 2006. In addition, consider the biotech projects of ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) that aim to use genetic engineering in their mandate crops that are specifically targeted at resource poor farmers (see http://www.icrisat.org/gt-bt/gt-bt.htm).
[2] For a large number of references to critical studies of various aspects of the Green Revolution, as well as studies representing the opposite point of view, see: (Shrum and Shenhav 1994).
[3] This was specifically argued by Niels Lauwaarts at ICAD conference, Wageningen, The Netherlands, October 2006. In addition, see (Leach and Scoones 2006) who argue that technological innovations (such as modern biotechnology) may potentially be development solutions, but are in practice often incapable of reaching their target due to the complex set of factors contributing to a problem they are supposed to solve (p. 20-26).
[4] The overarching research project, written by Guido Ruivenkamp, goes by the name "Genomics, between prescriptive code and social construction: an analysis of the constraints and possibilities for social choices in genomics for developing countries".

reconstruction of current biotechnology development is possible, in order to allow (bio)technologies to be shaped and reshaped in specific context and socio-political circumstances. These questions in turn require a further elaboration of a conceptual framework that rejects a vision of technology as *'fait accompli'*, and instead sketches room for manoeuvre to constantly reconstruct technologies to meet social needs.

A critical constructivist framework as proposed in this paper will not focus on the appropriateness of existing biotechnologies and ways to select 'the most appropriate technology'. Rather the focus is on processes of *endogenous technology development*[5], which are believed to be better attuned to local needs and circumstances and processes of sustainable development. This perspective moves beyond a mere technical agenda in terms of biotechnology development, as well as beyond notions that technology development has a certain 'impact' on social structures that needs to be managed. Rather, (bio)technology development is conceptualized in a larger historical framework in which technology development is part of a deeply social process (e.g. Ruivenkamp 1989, 2005). This process involves change at various levels, both in terms of practices, techniques, and efficiency, as well as in redefining social roles and relations of dependency and power. Because of these social aspects, the process in which technological innovations take place is fundamentally political, or rather *sub-political*[6], in terms of Ulrich Beck (Beck 1994).

An exploration of new approaches to (bio)technology development in LDCs will specifically aim at challenging political dimensions of technology development and at revealing the 'social choices' that are present in the process of technology development; i.e. the choices that relate to the shaping and changing of social roles and relations as part of the process of technological development. The central question is whether it is possible to envisage practices of technology development, in which a redefinition of social roles as part of technology development is not a passive side-effect that stakeholders have to adapt to, but rather a central and conscious part of development.

More concretely, in this paper constructivist and critical theoretical frameworks are being explored, to reach an appropriate and useful conceptualization of biotechnologies for development. The importance of a conceptualization of technologies as 'socio-technical ensembles' is discussed, rather than as mere objects. Moreover, technologies are claimed to

[5] The notion of endogenous development will be further elaborated later in this article.
[6] Sub-politics, the 'shaping of society from below' covers activities which take place outside the apparent political structure (Beck 1994, p.23).

feature important political dimensions, being value-laden, rather than having any 'neutral' status. This conceptualization of technologies is argued to be relevant in development studies. It is therefore taken as a starting point to rethink possibilities for tailoring technologies to processes of endogenous development. In doing so, the value of participatory methodologies in coming to a contextualized biotechnology development is re-evaluated. Aiming to take the proposed theoretical conceptualization of technologies seriously, an extension and refinement of participatory approaches is proposed.

2. A critical constructivist theory of technology development

In this section, two concepts are introduced that play an important role in conceptualizations of technology. They are (1) the notion of *co-construction* of technical and social aspects of technologies (as indicated by the idea of technologies as *socio-technical ensembles*), and (2) the notion of a *technical code*, relating the technology in technical terms to the larger social, political and economical regime it is a part of.

The relation between technological development and a social context has been elaborated by constructivist studies showing the social contingency of technology development. These studies have refuted technological determinism by emphasising that technology development is not a unilinear process, progressing from primitive technologies to advanced technologies, entirely according to some sort of internal logic and within a social vacuum. Rather, social constructivists have generally argued that technology development is the outcome of negotiation processes between social, economic and political stakeholders, while at the same time being restricted by technical limits and potentialities. Debates over the extent to which technologies are socially shaped (Bijker, et al. 1987, MacKenzie and Wajcman 1999), and on the other hand the extent to which technologies behave as social structures, having important impacts on social life (e.g. Sclove 1992), has resulted in a thesis of *co-construction* of technical and social elements, which are co-produced in the same process and therefore fundamentally interrelated. One concept introduced to indicate this nature of technology, is *'socio-technical ensemble'*, as has been introduced and elaborated by Wiebe Bijker and Trevor Pinch in their Social Construction of Technologies (SCOT) approach (Bijker 1995, Bijker, et al. 1987, Bijker and Law 1992). Bijker states:

> The sociotechnical is not to be treated merely as a combination of social and technical factors. It is sui generis. … Society is not determined by technology, nor is technology determined by society. Both emerge as two sides of the sociotechnical coin during the construction process of artefacts, facts and relevant social groups. (Bijker 1995, p. 274).

While acknowledging the valuable contributions in conceptualizing technology development from social constructivism, one aspect that deserves more emphasis in the conceptualizing of technological development is the idea that any social negotiation process (also when concerning technology development) takes place within certain structural historical and cultural settings which structure the negotiation process. Such an approach closely resonates with a critical theory of technology, which introduces the second key concept in this conceptual framework: *the technical code.*

Critical theory, as originated in the Frankfurter Schule[7], but more recently revised by authors such as Feenberg and Ruivenkamp (Feenberg 1999, Ruivenkamp 2005), has been an important theoretical framework for studying technological development within a wider social, political and historical framework. Critical theory has received significant attention for its critique on modern societies and the role of technology, but it has also suffered some severe criticism for overemphasizing structuring tendencies that marginalized human agency in technological development. Because of this lack of human agency, it appeared to be unable to offer a way out of the pessimistic, gloomy visions of future technological developments its followers described. Recent revisions of critical theory that inspire this research project aim to move beyond such an impasse, and try to bring back human/user agency in technology development (Feenberg 1999). This revised form of a critical theory of technology has some important things to say about technology development as social and political process.

Critical theory takes a more normative stand than social constructivism and has stressed the need to move away from a politically neutral, instrumental conceptualization of technology development. If technologies and social context are co-constructed in the same process, questions emerge regarding the social and political nature of technologies

[7] For more information about the Frankfurter Schule, see for example (Wiggershaus 1995)

themselves. More specifically, the following two questions are at the very heart of a discussion of the political nature of technology development: *'to what extent are technologies ideological or political, in the sense that they are able to structure or mediate social relations in a specific context?'*, and secondly, '*to what extent is a reconstruction of these ideological or political aspects of technologies possible?'* These questions cannot fully be answered in this paper; they reflect fundamental questions in theories of technology. However, a short outline will be given of the way in which these questions have been answered by scholars working on a modern revision of a critical theory of technology, and what they mean in light of this paper.

Langdon Winner is one of the scholars who has explicitly taken up the question to what extent technological artefacts are political[8] (Winner 1985). He has made two types of arguments regarding this political nature of technology. First, he describes instances in which the invention, design, or arrangement of a specific technical device or system becomes a way of settling an issue in a particular community. For example: the construction of parkways around New York, with low hanging overpasses prevented busses from using these parkways. This design contained an inherent bias giving preference to the richer (predominantly white) upper class that could afford their own automobiles, and therefore easily reach the recreational areas around the city.[9] Secondly, he states that there are cases of what can be called inherently political technologies, man-made systems that appear to require, or to be strongly compatible with, particular kinds of political relationships. Winner's example here is the use of nuclear energy, which he claims is highly compatible with hierarchical and centralized control, and an inclination by governments to infringe civil rights.

[8] While Winner formulates the question whether artefacts are political, Ruivenkamp introduced the notion of "politicizing" products (Ruivenkamp 1989, p. 354). Both terms are somewhat similar in the sense that they refer to an inherently political dimension of technologies. However, the term 'politicizing' stresses the processual nature of this political dimension, and therefore the inherent potentiality to redirect this process. However, the term 'policitizing' is also commonly used to refer to the act of 'making things subject to party politics and thereby obscuring a discussion of its proper features'. I thank an anonymous reviewer for this comment. In order to avoid confusion, in this paper the term 'political' is used, rather than 'politicizing'. The next section will further elaborate this political dimension of technologies.

[9] Winner's seminal article has not been uncontroversial, and especially the example of the parkways with low hanging overpasses has raised some debate (Joerges 1999, Woolgar and Cooper 1999). Moreover, the precise way in which artifacts can be said to 'have politics' remains question of debate (Latour 2004). Nonetheless, Winner's introduction of the notion that technical artifacts can reflect and reinforce social relations remains important for the argument presented here.

In a similar vein, Andrew Feenberg discusses the political content of technologies. In his critical theory of technologies, he describes technologies as having a 'technical code'. This technical code describes the technology in strictly technical terms, but in accordance with the social meaning it has acquired (Feenberg 1999). The technical code is that aspect of a technology that allows the embedding of social norms, cultural values, or a certain ideology within technology design. Considering that also unequal power relations will become embedded in and reinforced by technology design, technology development has been considered to have *an inherent bias towards social and ideological domination*. Technology has been claimed to be 'materialized ideology', because of the ability to embed and thereby reinforce unequal social relations, without being questioned by the ones that are dominated by it (e.g. Feenberg 1999, 7).

This supposed ideological dimension of technology is rarely being made explicit in contemporary discussions over technology development, but based upon the work of scholars like Feenberg, it may be expected to play an important role in processes of innovation and technical change. In this context, the notion of ideology can be described as a relatively coherent system of ideas and concepts, embodied in institutions, and which welds together social actors in pursuing prescribed goals. The precise meaning and function of 'ideology' has since long been ground for debate, the complexity and repercussions of which extend far beyond the scope of this paper[10]. However, one crucial notion is that 'the basic function of all ideology is to interpellate/constitute individuals as subjects' (Althusser in Laclau 1977, p. 100). This implies that the notion of an ideology cannot be reduced to some abstract ideas in society, but should be considered as a structuring force, concretely influencing actors' thoughts and actions. Ideology defined this way constitutes the basis of a hegemony of technological rationality, and legitimises existing structures of social domination.

Remarkably, these aspects of technologies normally remain invisible, since like culture, they appear self-evident. Feenberg states that 'the legitimating effectiveness of technology depends on unconsciousness of the cultural-political horizon under which it was designed.' He strikingly compares a feudal system in which the King was perceived as the natural source of power, with modern cultures in which technical rationality is unquestioned

[10] For example, compare notions of ideology and hegemony by Marx with those of Gramsci, Althusser and Laclau.

and accepted. This relates to a notion of hegemony, as once elaborated by Antonio Gramsci. Hegemony refers to the phenomenon that particular ideas, values, attitudes, beliefs are considered as *the* ideas, values, attitudes and beliefs and a natural order of how we have to think and do things. As such, hegemony is to be considered an 'organizing principle' of social practices, or in this case: technological practices (Gramsci 1971, Raphael 2003). In other words, it is an all-pervading type of domination which appears so natural to the ones dominated that they accept it.

This notion of hegemony seems to endanger an optimistic answering of the second question that was posed here: 'to what extent is a reconstruction of this technical code possible?' However, Feenberg adds that 'a critical theory of technology can uncover, demystify the illusion of technical necessity, and expose the relativity of the prevailing technical choices.' (Feenberg 1999, 87). This project of exposing the relativity of technical choices implies indicating the potentiality for social choices and therefore a re-introduction of human agency into technological development. This in turn is the main goal when implementing a critical constructivist framework. It is not only intended to provide a critical analysis, like Feenberg proposes, but also includes a constructivist element that uses the room for manoeuvre to actively propose a redesign of technologies.

3. Reinterpreting biotechnology development in less developed countries: the political dimension

This section relates the rather abstract theories of technology to more concrete studies of (bio)technologies in the context of development studies. Several authors have described elements of agricultural technologies that are problematic for groups of farmers in developing countries (Goodman, et al. 1987, Kloppenburg 1988, Pretty 2002, Ruivenkamp 1989), and have thus illustrated the need for a reconstruction of biotechnologies for LDCs. Their analyses move beyond identifying straightforward technical problems, but rather stress the political nature of modern biotechnologies and their power to redefine social roles internationally.

Goodman and colleagues have discussed processes of 'substitution' and 'appropriation' as part of an industrializing agricultural system. Substitution refers to the

process in which (bio)chemical substances replace agricultural products as raw materials for the food processing industry. As a result, farm products are being reduced to 'semi-manufactured industrial goods' that can in time themselves be replaced by synthetic industrial products. Appropriation refers to the gradual take-over of the controllable biological activities from farming practice by external institutions, especially by industry. These activities may include the production of seed, the breeding and selection of new crop varieties, managing the fertility of the soil, and pest management.

These processes are part of a development in which farmers increasingly lose control over aspects of the farming practice and are being reduced to 'workers in the open air' for a distant food processing industry. Researchers are argued to increasingly exercise remote management of farming practices, via the distribution of knowledge-intensive farming inputs such as seeds, fertilizer and biocides, which render the farmer dependent on external scientific or technological knowledge (Ruivenkamp 2003b).

Ruivenkamp has argued that these processes are taking place against a background of three main disconnection processes that are taking place in agricultural development in general (Ruivenkamp 1989, 2003a, 2003b, 2005). First a disconnection of the agricultural production and the natural environment has been widely described and criticized for its perceived unsustainability. Secondly, a disconnection process between agricultural products and food products is present, since many food products have become a mixture of chemical ingredients (protein, lipids, carbohydrates, vitamins, and additives) of which the original agricultural source is no longer visible, nor relevant. Of course, this process precisely allows the process of substitution as described above and elaborated by Goodman *et al*. Thirdly, partly as a result of the previous disconnection process, agricultural production becomes disconnected from food chains altogether, since the chemical compounds that constitute the agricultural products become ingredients for not only a food processing industry, but also for a chemical industry, or for the production of biofuels. These latter two disconnection processes are important constitutive elements of globalising food chains, in which a final type of disconnection process is salient: the disconnection of local production from local processing and consumption. Instead of dealing with local markets, farmers increasingly produce for very distant markets and therefore become vulnerable to international market fluctuations, trade barriers, and international competition with producers in entirely different

parts of the world. These processes are problematic for their associated loss of control of local farmers over their own livelihoods, and autonomy.

This analysis of disconnection processes has on the one hand led to pleas for a reconnection of 'people, land and nature' in order to achieve sustainable agricultural production (Pretty 2002), as well as to visions of multi-local agro-food networks which introduce new ways of thinking about producer/consumer relations (Manzini 2005). Alternatively, rather than reconnecting what has been increasingly separated in processes of economic globalization, active attempts to re-establish a certain level of autonomy and control in the hand of local communities, as part of internationalized food networks may be taken as a way forward.

4. Implications for thinking about technologies for development

The theoretical visions of technologies as socio-technical ensembles (as opposed to a common image of technologies as mere artefacts or objects), and as political entities[11] (as opposed to the generally widespread treatment of technologies as inherently neutral phenomena or tools) are not without repercussions. The notion of technologies as *socio-technical ensembles* implies that considering the introduction of technologies in development should not merely look at effects and risks, but should explicitly take on board the social relations around the technology. However, when looking at existing programmes, a continuum of different approaches to technological innovation as part of agricultural development can be recognized. The various positions along this continuum reflect different conceptualizations of technologies.

On one extreme one can position the rather widespread notion of a 'transfer of technologies'. In traditional versions of this approach, technologies are generally treated as relatively isolated, neutral tools. Successful technologies, developed in richer parts of the world, are transferred to developing countries to perform similar functions in the new

[11] These two dichotomies in thinking about technologies are of course interrelated: a conceptualization of technologies as objects is compatible with an instrumental view on technology development, while seeing technologies as partly social phenomena introduces sensitivity to the social and political dimensions of technological change.

context[12]. This model, which has characterized much of Western development strategy, has been widely criticized, e.g. for systematically imposing a uniform image of 'one good practice' developed by agricultural science on often diversified agricultural practices (Van der Ploeg and Long 1994). That said, the notion that transferring technologies *always* involves considering changes in their design, is generally well established. It is the *extent* to which transfer of technologies involves a redesign of technologies that may vary.

On the other end of the continuum, one can distinguish an alternative route which strengthens stakeholders' efforts to develop strategies for endogenous developments. In this strategy the aim is to elaborate the potentialities of local knowledge and natural and social resources with several stakeholders. This point has been elaborated by Van der Ploeg and Long, who stress the heterogeneity in styles of farming (Van der Ploeg and Long 1994) and state:

> '… endogenous development can revitalize and dynamize *(these)* local resources, which otherwise might decline or become superfluous. Furthermore, endogenous development practices tend to materialize as self-centred processes of growth: that is, relatively large parts of the total value generated through this type of development are re-allocated in the locality itself (Van der Ploeg and Long 1994, p. 2).

The technological developments that arise from such an approach could be regarded as 'born from within', rather than a scientific model imposed from outside.

Various other approaches can be found in between the extremes of a traditional 'transfer of technology' approach and fully endogenous technology development. One compromise may be the tailoring of new technologies such as genomics to the potentialities of local agriculture and food production. This approach would involve both elements of a transfer of technology, as well as explicit attempts to 'endogenize' the technology. The differences among the various approaches along the continuum then do not so much concern the malleability of technological *objects*, but relate to the level and extent to which the technology is being 'redesigned' as *socio-technical ensemble*. Note that participatory

[12] See e.g. the ABSP I (Agricultural Biotechnology Support Project) and ABSP II programmes that explicitly aim for a 'transfer of technology' approach. In linking up companies or research institutes from developed countries, owning a certain biotechnology, with local stakeholders in developing countries, the projects aim to make hi-tech agricultural solutions available to stakeholders in developing countries. See http://www.iia.msu.edu/absp/ and http://www.absp2.cornell.edu/ for more information about the projects.

methodologies -commonly applied in programmes of pro-poor biotechnology development today- can play a role at both levels and may be used within various strategies. In some cases, participatory design may refer to rather technical issues, while in other cases participation of end users redefines their social role as *receivers* into a role of *innovators* of technology.

The previously elaborated notions of technical code and the political dimensions of technology imply that *we cannot restrict ourselves to choosing the most appropriate technology from a list of available technological solutions, by whatever methodology*. The critical constructivist framework introduced here therefore strongly argues for technological innovation as part of endogenous development processes. Concretely, this may involve challenging social relations that are introduced by a further scientification of agriculture, challenging the conceptualization of agricultural problems in terms of genetics, challenging reductionist and monofactorial approaches to problem solving of complex problems and challenging the idea that adopting increasingly restrictive regulatory frameworks to accommodate increasingly complicated and risky technology is inevitable.

The notion of endogenous development can now be understood to have two important dimensions. The first relates to the idea that technology development cannot be considered in isolation of highly diversified local contexts, both in terms of farming systems, as well as in socio-economical and cultural context. Endogenous development therefore refers to technologies that are well grounded in specific localities. Secondly, endogenous refers to a sense of 'ownership', not necessarily in terms of actual property rights, but in terms of 'being in charge' of the developments that takes place. Rather than merely adopting technologies to local environmental, climatic or economic conditions, this calls for an active enrolment of local actors as innovators, rather than as receivers of (bio)technologies.

This second point stresses that 'endogenous' does not necessarily mean that technologies have to be developed in a specific local region. While geographical parameters may actually be of decreasing importance, it is the combination of local grounding and control that constitutes the ability to *endogenize* a technology.

5. Reconstruction: rethinking participatory methodologies in technology development

The critical analysis of the political bias in technology development invites us to take a closer look to the second question posed in this article: 'to what extent is a reconstruction of technologies possible?'. Taking the above into account, this question in fact refers to the extent that endogenous development of agricultural biotechnologies is possible, and to the extent that current approaches to development allow a redesign of these technologies.

The notion of endogenous development fits into a wider theoretical perspective on development that moves away from primarily economic analyses of development, a linear path to development, and a focus on urban growth centres. The 'alternative development approach' has instead aimed at taking local conditions and social relations as starting point for an analysis, not of how national economies can be encouraged to grow, but on how to alleviate poverty in marginalized (often rural) areas (Potter, et al. 2004).

One of the central elements in studies or programmes of 'alternative development' has been the use of participatory methods to ground development in a specific local situation, and to ensure sustainable learning, change and empowerment of communities. Next to practical goals in terms of improving the innovation process, this approach may serve an important social and political purpose in challenging the marginalization of poor farmer communities. Those who may be considered to be passive receivers of technological innovations, delivered to them by a supposed 'trickle down' effect, are now redefined as active participants in the process with legitimate demands, experiences and useful knowledge[13].

However, different levels of participation have been described[14]. Depending on the project and aims of involving stakeholders, users or consumers, various methodologies have been applied. The issue here is in what ways participatory methods are operationalized and whether this influences their ability to actually allow technological redesign.

These questions are addressed by studying the case of the Andhra Pradesh Netherlands Biotechnology Programme (APNLBP), in the Indian state of Andhra Pradesh.

[13] Important works addressing the issue of appropriate biotechnology development and the use of participatory processes in biotechnology development for resource poor farmers, are (Bunders 1988) and (Bunders and Broerse 1991). This paper relies strongly upon this essential groundwork, while attempting to move beyond it by asking additional questions about the political dimensions of biotechnology development in LDCs.

[14] Jules Pretty *et al* provide a 'typology of participation' in (Pretty 1995, p. 61), as well as some critical remarks on the value of some levels of participation for sustainable development.

The programme has been set up as a 'Special Programme on Biotechnology for Development' of the Dutch government and after a pre-project phase, work on projects has started in 1996. The programme was suggested as a potential mechanism to close the North-South gap through technology development, and was remarkable in its setup, since it embodied a conscious effort to build capacity and instil concern for biosafety issues within the recipient country, and to focus explicitly on 'resource-poor farmers in a participatory manner' (Clark, et al. 2002)[15].

In starting up, the programme encountered a challenge in having to deliver relatively rapid results to the group of involved stakeholders in order to maintain momentum and to gain legitimacy among local farmers as a helpful programme. However, the development of some modern biotechnologies that might be useful to address some of the problems that had been identified and prioritized in earlier workshops, would take considerable time. Therefore, the programme has made a strategic decision in focusing on traditional biotechnologies, like tissue culture, vermiculture and biopesticides, in its first operational phase. In doing so, the programme aimed to build support for the projects. Moreover, it was expected that the need for more sophisticated technologies would emerge along the way. In practice, a small number of advanced biotechnology projects were started in parallel, some of which involve transgenic technology. This situation provides an interesting starting point for comparing both types of projects that were part of the same programme. With respect to the conceptualization of technology, as operationalized in the innovation process, important differences emerge.

The commonly followed participatory approach within the APNLBP is to have a workshop with local farmers, NGOs and scientists in which priorities for farming innovations, or pest management are determined. These priorities are studied to determine whether ready-made solutions can already be found. If not, the demand articulated in the workshop will be translated into a scientific question which will allow (molecular) scientists to work on a specific topic and to come with potential solutions. These solutions are then incorporated into new products or crops and evaluated with the end-users[16].

[15] The review of Clark et al provides a great overview of the various phases in the programme and how bottom-up learning processes fit into thinking of innovation systems. More information about this programme can also be found online at http://www.apnlbp.org/
[16] Prof. Pakki Reddy in personal communication, November 2005

One of the projects that involved the development of modern biotechnologies, is the project working on isolating stress inducible genes from pigeonpea (Cajanus Cajan L.). This project showed a typical feature that emerges in some participatory projects, which is an implicit *separation of phases of priority setting, technology design, and evaluation of the technology*. Starting from the prioritized aim to develop crops that would be better able to cope with the arid conditions in the state of Andhra Pradesh, the project set out to isolate genes responsible for drought resistance in pigeonpea that may be isolated, characterised and later transferred to target crops like groundnut, castor or sorghum[17]. This implies that a trajectory has been set out to battle drought tolerance in these target crops, through a transgenic approach, since crossings of pigeonpea and the target crops are not possible. The participatory element in the project, identifying both priority traits and crops did not extent to the long-term strategies taken and the repercussion of this strategy for biosafety issues, regulatory affairs or the redefinition of social roles that goes along with these strategies.

A key point in the participatory process adopted for this project is the translation of certain user (farmer) needs or desires, into a scientific problem statement. After solving the identified problem at the scientific level, the solution can be disseminated to farmer groups again, accompanied by participatory evaluation schemes. This process is clearly executable and can result in extensive communication between scientist and farmer. However, it shows a conceptualization of the innovative technology as an object or tool that will solve the problems prioritized in communication. This will usually not be considered problematic, as long as there is enough communication between scientists and end-users to guarantee a technology design that is attuned to their needs and circumstances. However, the approach does imply clear limits regarding the extent to which technology development can be steered in different directions; if only because the translation of farmer/consumer needs into a scientific problem is not challenged in a participatory vein. In fact, the scientist and his vocabulary of possible solutions is never being challenged as 'obligatory point of passage'[18] in coming to new, improved technologies or farming practice. Neither is the implicit ideology of a rather reductionist approach to technological progress in farming practices challenged in any way.

[17] Interview data

[18] The term 'obligatory point of passage' is borrowed from actor-network theory in which a central actor attempts to stabilize a network, aligning other actors in the same network, while becoming an 'obligatory point of passage' for all actors in the network. See e.g. (Callon 1986).

The failure to challenge the position of the scientist in translating the farmer's need into a scientific research question is related to the conceptualization of the technological solution as an object, rather than as socio-technical ensemble. The introduction of transgenics in the farming systems of resource poor farmers in Andhra Pradesh can be expected to go along with much more fundamental changes in farming practice and regulatory regimes. While a conceptualization of technologies as objects places the technological solution centre stage and will deal with the socio-economic effects afterwards, a conceptualization of technologies as socio-technical ensembles would choose to involve end-users or stakeholders in the entire process of innovation and technology design, since the integration of new technologies is as much a social affair, as it is a technical affair. The reasons for stakeholder involvement are then to reach a process of iterative, reflexive technology design, in which the distinction between phases of design and evaluation is fading. A much more fundamental challenging of positions of central actors is a result of such a dynamic. Farmers or other end-users are not only addressed as 'consumers' of technology, but are recognized as innovators themselves. This in turn would qualify the resulting technology development as much more 'endogenous', since the technology is not only grounded within the specific local context, but also attributes a powerful role to the farmers themselves.

Although the methodological separation of phases of prioritizing, design and evaluation may occur in any programme, especially the development of modern biotechnologies (genomics, genetic modification), which demand a higher level of scientific expertise, seem to stimulate such separation of phases of design and evaluation. The extent to which farming innovations are not only about introducing new technological artefacts or tools, but are explicitly engaged in the production of new social roles, becomes clear from the study of some other projects within APNLBP, focusing on more traditional biotechnologies.

Some projects have focused on vermiculture production, which can be carried out at household level, and gives rise to biological fertilizer which can be used to increase the fertility of the soil. The same product can be used for the rooting and hardening of tissue culture plantlets, which is traditionally a step that is carried out under controlled laboratory conditions, in agar medium. The transformation of this step from the laboratory to the field, and from lab assistant to farmer has significant implications for the social roles that are being shaped around this technology. Next to the much cheaper production of virus-free plantlets, bringing them within reach of resource poor farmers, farmers gain a central role in the

production of tissue culture plants, redefining them from passive receivers, to active innovators. Similarly, as part of the same program, the production of a Bt-spray (to be used as bio-pesticide[19]), shows a process of redesign that allows a decentralization and an active involvement of villagers. Traditionally, the production of Bt required specialized equipment and a continuous power supply. By redesigning the production process, allowing the fermentation to take place in a solid medium rather than in liquid medium, cheap and locally available materials can be used. This allows the process to take place at village level, where the farmers themselves are actively involved in producing their bio-pesticide (Puente, et al. 2006, Vimala Devi and Rao 2005).

Also in these projects, the methodological separation of phases is apparent. Still, where the drought resistance project marginalized the farmer's role in the innovation process, by taking the project to that lab and treating the technology in relative isolation of the wider socio-economic repercussions of embarking upon the use of transgenic crops, the other projects enabled farmers to be more involved in the process of innovation itself. By doing so, the concrete products developed in these projects of the APNLBP programme serve an important sub-political function. This demonstrates how technologies may be conceptualized as socio-technical ensembles, but how at the same time the concrete characteristics of the technological artefact itself remain highly relevant.

Summarizing, participation with respect to 'technologies as objects' runs the risk of framing the participatory issues too narrow, allowing a smoothly running participatory process, but limiting the range of potential outcomes. Therefore, the ability to distinguish between levels of participation, and to apply the appropriate one with respect to the goals set, is crucial. Participation *can* be a powerful part of articulating and developing alternative technology development trajectories, but it needs to operationalize a conceptualization of technologies as socio-technical ensembles, rather than as objects. It needs to open up the black box of what in effect technologies are, revealing the relevant social and political dimensions that need to be addressed if a reconstruction of (bio)technologies is to take place.

[19] Bt is an abbreviation of Bacillus thuringiensis, a bacterium that produces certain proteins that are toxic for pest insects. Local strains of Bt are isolated, multiplied and processed into a spray that can be used in safe, sustainable and affordable pest management.

6. Synthesis: moving beyond uncritical approaches to biotechnology development in LDCs

The stakes in technology development in, or for less developed countries are high. Treating technology development as a process with important social and political dimensions, we have raised the question whether more attention should be paid to the ability of technologies to redefine social roles and relations. Concretely, theoretical discussions about the nature of technological development and its relation to social and political relations have led to a discussion of possibilities for reconstruction and a rethinking of participatory methodologies in development programmes.

While several approaches to participation and increasing innovation capacities may be legitimate in different situations, in this paper an explicit argument has been set up to consider a fundamental reconstruction of technologies that does not only address the technical level, but also reconfigures political aspects of technologies. This involves both *acknowledging* and *challenging* the political dimensions in technology development. However, highlighting these social and political dimensions of technology development does not mean that negotiations at the level of the technical object have become obsolete. On the contrary, acknowledging the political elements as part of the technical code of technological objects is part of opening the black box of agricultural biotechnologies. Challenging these dimensions, inscribing technologies with a different technical code, and reconstructing them to fit local needs and circumstances can explicitly and particularly take place at object level. The challenge is all about taking up the sub-political dimensions of technology development and using them to develop biotechnologies as part of processes of endogenous development.

Achieving such a sub-political technology development requires a further elaboration and refinement of methodologies of participation, as they are considered indispensable in taking up the proposed sub-political technology development. In practice, this means that a number of new and additional research questions needs to be asked. Of course questions regarding priorities and the technical appropriateness of technologies in certain contexts are still necessary and legitimate. But they should be complemented with questions about how technology is conceptualized in various development programmes and what the consequences are for the involvement of stakeholders in technology development. Will a

conceptualization of technologies as socio-technical ensembles allow a different involvement of stakeholders in which they are not only involved in phases of priority setting and evaluation, but are actively involved in an iterative process of technology design? Can a conceptualization of technologies as political phenomena gather momentum to create room for manoeuvre to develop alternative trajectories of biotechnology and genomics developments? Can these conceptualizations of technologies ensure that values in technology development are the central point of focus, rather than procedures and formal structures?

Asking these additional questions in effect implies an infusion of a critical dimension into current and commonly applied frameworks in technology development. *Finding answers* to these questions may provide the room for manoeuvre needed to develop, reveal, or even to simply recognize alternative trajectories to biotechnology and genomics development. Such approaches to agricultural development would treat technology development as inherently social process and may include values such as autonomy, independence and long term sustainable development.

Lifting the veil of an ideology of technical rationality shows the presence of social choices, prevalent in any technological development process. Tensions or contradictions in current development processes can provide momentum to making other choices. That way, the sub-political element that is so pervasive in technology development, is no longer an unpleasant side-effect, but can be taken up as a new arena of political struggle and the formation of new identities.

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