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Contextualised Science and Technology Policies – the Need for Articulation of Need

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Synopsis

Science and technology can play a key role in contributing to the sustainable development of developing countries. However, research has failed to relieve the problems of Southern communities and to respond to the needs of its poor. There is the need to develop holistic and contextualised science and technology policies in the South, which respond to the social, cultural, political and economic environment and reflect the demands and priorities of various stakeholders. Recognising the inequalities present in developing countries, this thesis addresses the need to ensure the articulation and inclusion of the needs of poor in S&T policy making. The thesis explores how contemporary conceptualisation of knowledge production may contribute to more context-sensitive S&T policy making in developing countries and strengthen its relevance towards meeting the needs of the poor. It argues for the need for flexible and networked approaches to knowledge production, and for recognition of the way social processes include and exclude the articulation of needs.

Key words: Mode 2, SCOT, Science and Technology Policy, Demand oriented research, Policy Dialogue

Preface

First of all I wish to thank the participants at the *Providing Demand* workshop for sharing with me their views on the topic, and in particular my key informants who took the time during a busy meeting schedule to meet with me and elaborate on their views.

A special thanks to Andy Hall at the UNU/INTECH for helping me with the case studies and for his interest and valuable input to my work

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The support from friends has encouraged me, particular thanks to Heidi and Marianne for being there, and here when I needed you the most! Finally, to my parents for always standing beside me and supporting me in what I do, thank you.

Abbreviations

AIVIA – All India Village Industries Association

CAPART – Council for Advancement of Peoples Action for Rural Technologies

CSIR – Council for Scientific and Industrial Research

CSV – Centre of Sciences for Villages

DSIR – Department of Scientific and Industrial Research, India

DST – Department of Science and Technology, India

GMO – Genetically Modified Organism

ICAR – Indian Council for Agricultural Research

IDE (I) – International Development Enterprises (India)

IIT – Indian Institutes of Technology

MCRC – Shri AMM Murugappa Chettiar Research Centre

NGO – Non-Governmental Organisation

R&D – Research and Development

UNU/INTECH – United Nations University, Institute for New Technology

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1. Introduction

There is a lack of sensitivity to the needs of the poor, in terms of setting the research agenda and in terms of delivering the products of research towards benefiting those people, and this is the general scenario.

Arunachalam Subbiah, M.S. Swaminathan Research Foundation,
10th of May 2004, Providing Demand workshop, Leiden

The Human Development Report 2001 argues that new technologies can contribute to reducing poverty and offer opportunities of transforming the lives of poor people. However, these opportunities are missed as science and technology (S&T) respond to the demands of capital interests, while governments in developing and developed countries alike have failed to support development-oriented S&T. (UNDP 2001) Instead there is an increasing inequality between developed countries, referred to as "the North" and developing countries, referred to as "the South". This is accelerated by rapid technological change in the North and the emergence of a global knowledge society, where systematic knowledge is central to decision-making in ever more areas.

In a lecture at the University of Maastricht, (March 2004)[1] Jan Pronk, the former Dutch minister of foreign affairs, described a globalisation where knowledge and access to knowledge becomes increasingly important, while at the same time, the inequality increases between those with access and those who are excluded. This inequality is present between North and the South, but it is also present within societies between knowledge rich and resource poor. Arunachalam Subbiah spoke from the perspective of his native India, but the same general scenario as he spoke of may well describe the situation of (S&T) in most developing countries, and of the research agenda in the world as a whole.

The development of S&T in the South has suffered under the lack of infrastructure and framework for indigenous S&T policies. In cases where S&T has been promoted it has often

[1] Guest lecturer on Globalisation and Inequality, University of Maastricht *Minor Globalisation and Diversity*

been for large prestigious projects, while its potential of contributing to social and economic improvement for the general population has been neglected.

Developmental aid and international development cooperation failed for a long time to see the importance of indigenous S&T. Instead, scientists from the south have been brought to universities in the north for training through bilateral state-level projects and technology developed in the north has been transferred to developing countries. In many cases, neither the training nor the transferred technology has been relevant to solve problems in the south, while the recourses invested and the capacities that were built stayed in the north. In the late 1980s, the Farmer First series, inspired by Chambers et al. (1989), argued the importance in agricultural research of seeing the needs of farmers in the south, and for the use of participatory methods to articulate and develop their needs into research problems.

The general problem then is how S&T can become more relevant to the needs of developing countries and in particular sensitive to the needs of poor

1.1. From Demanding Innovation to Providing Demand

Recognition of the need for a Southern perspective in innovation, and of placing the demands of the people in the developing world at the core of S&T policy, led in 2001 to the organisation of the international conference *Demanding Innovation - Articulating Policies for Demand-led Research Capacity Building*[2]. The conference discussed the issue of demand oriented S&T in developing countries and experiences with research capacity building under the auspices of a policy of S&T for development that aimed "to link research more closely to the needs and interests of the developing world, particularly the poor". (Bautista et al. 2001)

[2] Demanding Innovation: Articulating Policies for Demand-led Research Capacity Building, 10-12 October 2001, Maastricht, the Netherlands, Organised by the European Centre for Development Policy Management (ECDPM) and the Netherlands Ministry of Foreign Affairs (DGIS)

The conference concluded that research in the South has failed to contribute to sustainable development much because of an orientation towards academic and northern concerns, instead of towards concrete issues and relevant problems of the south. It called for the development of demand-led research with increased interaction between researchers and end-users and thereby increased sensitivity to the needs of the society. (Maastricht Declaration, 2001)

As Thandika Mkandawire (2001) pointed out during the conference, it is important to be aware that demands can come from several and possibly contradictory positions and whose demands that are prioritised depends on a wide range of issues. Hameeda Hossein (2001) argued that demand generated by government or donors will be according to their criteria and not necessarily responding to the needs of the community.

Recognising that the social groups that are involved in defining the problems also have power over the solution to the problem, how then are research priorities currently being set in different developing countries, and which actors are involved in the dialogue leading up to such priorities? These were among the questions that were carried to a workshop three years later, in May 2004 *Providing Demand – Knowledge-intensive policy preparation and priority setting in development oriented research*[3]. During this workshop, authors from the South and the North, working in research institutes, aid agencies, non-governmental organisations, private and public sector addressed the issue of knowledge-based development strategies.

The workshop offered a unique opportunity for fieldwork where the rich diversity of approached presented allowed for exploration of the contemporary conceptual debate. Meeting and listening to discussions among experts, coming from a variety of directions to

[3] Providing Demand – Knowledge-intensive policy preparation and priority setting in development-oriented research, 10-12 May 2004, Leiden, the Netherlands. Organised by Louk Box, Professor of international cooperation in the Department of Technology and Society Studies at Maastricht University, Funded by DGIS

the issue of S&T for development, highlighted the complexity of the field and the need to contextualise the approaches.

Among the presentations at the workshop, there was diversity in terms of the epistemological position of the authors; constructivists and rationalists, in terms of the modes of intervention; arguing for institutional capacity building, regional initiatives and private public partnerships, and finally with regard to the articulation of demand for priority setting; centralist and participatory. (Box, 2004, p. 3)

The different positions in dealing with demand articulation was on the one side represented by Osita Ogbu[4](2004) and Sunil Mani[5] (2004) who emphasis the need for central coordination of S&T policies and the importance of knowledge-based decision-making. They argue for a top-down approach where an increased stock of knowledge will enable the government to make better decisions, based on actual needs and their own agenda, catering to the needs of their societies as a whole, and not to particular sectoral interests or the agendas of international donors or other institutional agencies.

In contrast, Arunachalam Subbiah[6] (2004) argues for a bottom-up approach where S&T policies should be guided by a wider set of interests and by civil society in particular. For S&T to have an impact on the lives of the poor its direction can not be set by the government alone, but must be influenced by civil society. Mechanisms for the articulation of needs must be established and this should then be the base for S&T policies and further policy making.

The two positions lean towards the two distinct types of knowledge production developed by Gibbons et al. (1994) in the concept of Mode 1(Ogbu and Mani) and Mode

[4] Osita Ogbu is Executive Director at the African Technology Policy Studies Network (ATPS), based in Nairobi, Kenya

[5] Sunil Mani is researcher at the United Nations University, Institute for New Technology (UNU/INTECH) based in Maastricht, the Netherlands

[6] Arunachalam Subbiah is researcher at the M.S. Swaminathan Foundation (MSSRF), based in Chennai, India

2(Subbiah) Wiebe Bijker offers a different approach, arguing for a constructivist perspective on knowledge production. He presented a methodology and toolbox for establishing S&T policies through policy dialogue and thereby accommodating demand articulation. In this thesis I will take a closer look at these two conceptualisations, the Gibbons thesis and Bijkers social constructivist approach.

1.2. Aims and objective

Recognising the need for building an indigenous S&T base in the South; recognising the need for developing countries to set their own goals and priorities for the S&T agenda; recognising that this S&T policy must be based on the social, cultural, political and economic context and respond to demands from a variety of interests, the problem narrowed down for this thesis is how to ensure the articulation of a variety of needs in S&T policy making.

The general objective of this thesis is to discuss the relevance of contemporary conceptualisations of knowledge production in contributing to a more context-sensitive and needs-oriented S&T in developing countries.

I aim to present and discuss the Gibbons theory in light of its relevance for development oriented research and the critique presented by various authors. (Weingart, 1997; Box, 2001; Mouton, 2004) I will present three empirical cases of needs articulation in a developmental context and reflect on the usefulness of the Mode 1 - Mode 2 distinction in describing the knowledge production.

Subsequently I will present the social constructivist perspective and revisit the three empirical cases in the light of the SCOT approach. (Pinch & Bijker, 1987; Bijker, 2001;

Bijker, Leonards & Wackers, 2001) I aim to discuss the relevance of this epistemological perspective for S&T policy making.

1.3. Methods

This thesis is based on parallel gathering of theoretical and empirical material. In the period running up to the Providing Demand workshop in May 2004, I studied material on the workshop as well as the previous conference in 2001, presentations, background material and relevant reference literature. Furthermore, meetings with workshop authors, (Wiebe Bijker and Lea Velho) and organisers (Louk Box and Irene Olaussen) gave me directions and references to pursue.

During the workshop I observed presentations and discussions, presented in a draft report of proceedings, to the organiser, Louk Box. This allowed me to return to the various contributions, by means of the outlines and drafts delivered by the authors, as well as my report on the discussion at the workshop. In addition to observation, I had the possibility to meet with eight of the participating authors. Through these key informants, I was able to elaborate further on a number of aspects in the workshop. The references in my thesis to material from the workshop, relates to the draft report of proceedings and the transcribed interviews that have been verified by the key informants. Key informants are presented in the appendix.

Following the workshop, I chose to take a further look at the direction suggested by Arunachalam Subbiah and consider the role played by civil society in articulating demand in research. I selected a case study of the non-governmental research organisation MCRC, by

Shambu Prasad (2004), who in turn referred me to Andy Hall at the United Nations University, Institute for New Technology (UNU/INTECH) in Maastricht. Hall provided me with a second case, of the non-governmental organisation IDE, which facilitates research and technology development through the interaction of various actors. He has also checked my presentation of the two organisations. In order to allow for a broader perspective I included the case of a project based on a private-public partnership, suggested to me by Louk Box and collected through lecture material, and interviews with the key project developer at the company in question. As the project is waiting for final approval, the company name and details are left out for the sake of anonymity. However, the material has been verified by the key informant and checked with my supervisor. The three cases are focused on the context of India and the needs of small farmers and rural poor, they are set outside the traditional public S&T establishment and are selected based on the variety and novelty of their approach to ensure articulation of a broad set of needs in S&T development. They contain lessons on how to stimulate innovative public policies that responds to the interests of a broad set of stakeholders and care for need of the poor.

The theoretical material used in my thesis, stems from different strands within the field of STS studies. On the one hand science policy literature, with changes and trends described by Elzinga and Jamison (1995) and Weingart (1996) and analysed in the Mode 2 concept of Gibbons et al. (1994). On the other hand I use literature from the sociology of scientific knowledge and sub-fields in the empirical program of relativism (EPOR) and particularly the social construction of technology (SCOT) developed by Bijker. (Bijker et al., 1987), (Bijker 2001) Thirdly, I bring in S&T for development literature, with theoretical perspectives described by Shrum and Shenhav (1995) and material related to the Demanding Innovation conference (2001) and the Providing Demand workshop (2004).

1.4. Outline

In my following chapter I will introduce the science policy perspective. I will present the changing agendas in science policy as well as evolving theories of the role of S&T for development, before turning to the contribution by Gibbons et al. (1994) recounting a shift from a Mode 1 to a Mode 2 within a distributive system of knowledge production. I will discuss the relevance of the Mode 2 model and its potential contribution in orienting S&T towards the needs of southern societies. In chapter three, I turn to the south and present three cases of pro-poor research and technology development. I will discuss the relevance of the Mode 2 model in describing the form of knowledge production and argue that the examples are more complex than the modes allow for, including elements of both. In chapter four, I will explore how a social constructivist perspective of S&T may contribute to a better understanding of the influence of the different stakeholders in the process of research and technology development in the cases described above. Subsequently I will broaden the perspective again to the process of setting science and technology policies, using contributions to the Providing Demand workshop and argue that the choice for a constructivist approach allow networked articulation among diverse actors in policy making. Finally, the concluding chapter will sum up my findings as responding to the aims and objectives presented above.

1.5. Limitations

Time constraints have not allowed for the consideration that the complexity of issues presented at the *Providing Demand* workshop deserve. For the purpose of this thesis, the Gibbons theory and the social constructivist approach of Bijker have been chosen to gain insight in the diversity and context of demand articulation.

The limited number of cases studied does not allow for generalisation of the way demands are articulated, and the focus on India does not allow for generalisation of the situation in developing countries, the three cases may however, indicate limitations to the use of the theoretical approaches.

2. Conceptual framework

The important role played by science and technology in social and economic development has been recognised in Northern countries, through supportive S&T policy frameworks and funding. However, research efforts have failed to bring about sustainable development of societies in the South. The 2001 Maastricht conference Demanding Innovation – Articulating Policies for Demand-led Research Capacity Building, recognised that this was to a large extent due to "the academic orientation of local research and the prevalence of Northern paradigms rather than being oriented towards concrete issues and problems confronting the South" (Maastricht Declaration, 2001). Meanwhile, in a review of S&T policies in ACP countries, Box et al. (2000) found that there is little or no priority for S&T in the countries themselves, with only few countries mentioning S&T in their country strategy papers under the EU-ACP Cotonou Agreement. What then have been the Northern paradigms in science and technology, and how has this affected the approach to S&T for development?

After a look at the changing orientations in science policy I will introduce the contribution by Gibbons et al. (1994). Their description of a new Mode 2 form of knowledge production has caught the interests of demand-oriented researchers within the development field, as a model for a more socially accountable and relevant science, but it has also been met with criticism. Can a shift towards Mode 2 make S&T more oriented towards the needs of the southern communities, or is it just another Northern paradigm, unsuitable to capture the context of developing countries.

2.1. Changing paradigms in science and technology Policy

A distinction can be made between science policy and politics for science. Science policy is the governmental efforts to support S&T capacity development, through funding and expanding the science sector, while at the same time making use of scientific knowledge in policy making and exploiting its results to reach political aims. Politics for science concerns the interaction between science and power, as the social control over knowledge or the use of science by interest groups or in conflicts to increase power and influence. (Foss Hansen, 2002, p. 44)

The changing agendas in science and technology policy can be presented through various periodisations, depending on what interests are being represented and accordingly, what has been viewed as key-developments and turning points. Elzinga and Jamison (1995) have categorised these representations into four interest groups or policy cultures, with different political and social interests that try to influence and steer the direction of science and technology; 1) the bureaucratic policy culture, which is concerned with the use of science in policy making; 2) the academic culture, which is concerned with the support of science and keeping traditional values, 3) the economic culture, which is focused on technological use of science and its possible commercialisation, and finally, 4) the civic culture, which is concerned with the social consequences of science and politics for science. The changing agendas in S&T are seen as the result of interplay between these different stakeholders. Generally there has been a move from policies mainly concerned with the interests of the academic culture to an increasing need to respond to demands from political as well as increasingly economic and civil interests.

2.1.1. Science push in the 1950s and 1960s

Science policy became a governmental instrument for development in the North after the Second World War. In the interwar years, the Soviet Union had boosted science and technology through state steering and support, and also in the west, where upon till this point, the private sector had mainly been in charge, scientists were calling for greater state involvement. Experience with large-scale military research during the War, gave the push that was needed and in the period after the War all industrialised nations took on an active state involvement in scientific and technological research through investment and institution building. The state left, however, the freedom to steer the priorities to the academic culture itself, along the lines of Robert Merton's institutional norms of science. (Elzinga & Jamison 1995, p. 582) In 1945 Vannevar Bush wrote the report "Science: The Endless Frontier", which argued for political, economic and social autonomy for scientists. In this first period, science councils and national laboratories were established, the public had confidence in science, and scientists had confidence in their role as "frontier men", unsullied by "dirty" money or the needs of society.

In the "science push" model, scientists were forging ahead and breaking new ground without looking back how the results were used, accountable only to their peers. Science was considered the first step to any technological development, explained through a linear model, or conceptualisation of the relationship between science and economic production. In this linear concept it is thought that investments in basic research will generate knowledge that trickles down through a chain of adaptive research, engineering and manufacturing, before eventually appearing as a product that can be sold to the end-user. There is institutional separation between the different stages in the innovative process, and no contact between the initial scientific researcher and the end user. (Prasad, 2003, p. 53)

This linear view was also reflected in the modernisation theory of development, which regarded science as strongly linked to technology and important for a how well a country could make use of its own resources and thereby creating growth. As a result, the best way to support developing countries was thought to be through technology transfers and scientific and technical assistance. With scientific knowledge and the technology in place, the developing countries were expected to take off in the same direction as the industrialised world. (Shrum & Shenhav, 1995, p. 629)

The Cold War threats meant significant public financial support for military research. In the 1960s, after the Soviet Union had launched Sputnik, budgets accelerated in the West. Investments were also motivated by economic growth and the view of science and education as productive factors. Scientists were given the role of experts in more areas and scientific advisory councils were set up to advice politicians and public institutions. But the hegemonic role of scientists and the academic culture was beginning to crack. In the mid-1960s, science studies units were set up and empirical studies of innovations began to criticise the linear view of development; the assumption that investments in science led directly to economic growth was questioned from the bureaucratic side. Adding to this, increasing questions on the uses and consequences of science were asked from civic interests, along with tensions around the role science had played in the Vietnam War. With cutbacks in government funding different notions of relevance began to put pressure on science, from the bureaucratic and the civic cultures as to how science was put to use, but also from academia itself as to how to prioritise in science. (Elzinga & Jamison, 1995, pp. 584-587)

2.1.2. Increasing demands from bureaucratic and civic interests in the 1970s

In the 1970s, science was seen as a problem solver but also increasingly criticised as a problem maker. With stagnating industrial production in the west and increasing unemployment after the oil crisis of 1973, there were large tasks to manage in society and as science had to show its relevance in view of these tasks, a “demand pull” was beginning to work on science. With less money in the hands of governments, scientists had to show results; mission orientation and technology policy became new concepts as bureaucratic and economic interests allied. Meanwhile, the peace movement reacted on the nuclear race and demanded that money for research should go to civilian, rather than military uses, and civil society movements concerned with environmentalism and feminism placed new issues on the S&T agendas. Scientific expertise was no longer taken for granted. Alternative energy or the use of contraceptive pills became part of the public debate, and opposing sides in the debates could present scientific evidence in their favour, thus showing that expertise was contestable. The demands increased for science to be socially relevant and accountable, and studies in the field of science, technology and society (STS) spread. Towards the end of the period academic interests claimed that the call for social relevance had gone too far and that authority had to be given back to the experts. Furthermore, slowing economic growth rates gave strength to conservative torrents and contributed to an orientation away from civic-, and more towards economic interests. (Idem. pp. 587-590)

In developing countries questions had also been asked about the uses and consequences of S&T and what role the technology transfer from developed countries played. While modernisation theory had seen development as internal to a country and technological assistance as a contribution to this, dependency theory argued that external factors curb development. Western science is viewed as another way for industrialised countries to dominate, through imposing an inappropriate development model and not taking the needs of developing countries into account. (Shrum & Shenhav, 1995, p. 630)

2.1.3. Parallel processes of user orientation and globalisation in the 1980s and 1990s

In the 1980s, western governments turned the focus to the economic and technological challenge of newly industrialised countries in East Asia, and particularly Japan. While technology assessment and social relevance had been catchwords of the 1970s, so did the Japanese use of technology foresight and industrial orientation set the example for the 1980s. Neo-liberal economics was seen as the new cure and science as a strategic resource. National programs with an emphasis on closer relations between universities and industry were developed to support new technologies and the focus on strategic research introduced new ways of cooperating, for example through establishment of science parks. New fields like information and communication technologies, biotechnology and genetic engineering were appearing. Science was becoming user oriented and the demands from the economic culture came to dominate.

These tendencies continued in the 1990s, with coordinated and outcome oriented research, new technologies and fields of science, and new ways of working both for individual scientists and for the institutions. But new issued also came up, and notions like globalisation, sustainable development and public transparency became policy imperatives.

Growing international concern for the environment as well as the radical possibilities presented by new technologies like genetic engineering did again bring civil society demands into the light, joined with academic voices, critical to the strong links with industry. Science and Technology policies are on the one hand contingent to the process of globalisation, with harmonisation of policies and practices, through structures, patents and standards, and on the other hand increasingly aware of the need to consider national strengths and contexts. (Elzinga & Jamison, 1995, pp. 591-597)

Isomorphism, the adoption of structurally similar forms throughout the world is described in institutional theory of development. This theory argues that because of the belief in a universal and context-free system of science, and its necessity for modernisation, the western organisational forms have been seen as successful models and therefore copied by less developed countries over the past decades. (Shrum & Shenhav, 1995, p. 631) Developing countries adopt forms of knowledge production from developed countries and scientists that are trained in the west are linked to international scientific networks. However, though this knowledge production may prove to be compatible and comparable with western science, it does not necessarily provide solutions to national problems or answers to local needs. Civic movements in developing countries are challenging the established mode of knowledge production and call for a more socially accountable and responsible science, in accordance with local needs and context.

Next to the changing paradigms in science policy, from science push to demand pull, a different discourse was concerned with the issue of underdevelopment and the role of S&T in development cooperation between North and South. Modernisation theory and technology transfer had dominated the approach to science and technology in international development cooperation since the 1950s and 1960s, and bilateral cooperation and state-led initiatives were seen as the way of bringing industrialisation and economic growth to less developed countries. However, international research and government level initiatives were criticised for its top down-approach, producing solutions that were not relevant or adapted to the needs of local communities and the poor.

Calls for a different approach to science and technology in development cooperation increased in the 1980s and 1990s. (Chambers et al., 1989) Instead of top-down, state led technology transfers; it should now be bottom up, participatory research and development. In development research, the focus shifted from macro-level analysis to micro projects, from capital-intensive industrial technology to labour intensive rural technology, from scientific expertise to indigenous knowledge and direct stakeholder participation. The pendulum swung from the one end to the other, and to describe the two poles, the conceptual framework of Gibbons et al. was used, with the notions of Mode 1 and Mode 2 of knowledge production.

2.2. "The New Production of Knowledge" - Mode 2

Gibbons, Limoges, Novotny, Schwartzman, Scott and Throw published their book on "the New Production of Knowledge" in 1994, as a description of trends in knowledge production. Their thesis is that these trends together form a new type of knowledge production, which they call Mode 2. According to the Gibbons thesis, Mode 2 grows out of and exists alongside the traditional form of knowledge production, Mode 1. The latter refers to "a complex of ideas, methods, values, norms – that has grown up to control the diffusion of the Newtonian model" (Gibbons et al., 1994, p. 2) this means the social and cognitive norms to follow, the definition of problems, the search for solutions, the quality criteria and the definition of who is a scientists, i.e. the institutions of science. The authors characterise knowledge production in Mode 1 as primarily taking place within the university system, situated in an academic context and disciplinary based. The organisation is hierarchical and self-supplementing, with internal quality criteria assessed through peer-review. (See table 1 below).

The authors have pointed out several developments in the North as background for what they see as the advance of an alternative Mode 2. One is the massification of higher education where the number of graduates exceeds the available space in the academic world and in their discipline, and which has resulted a in a large supply of expertise and a spill-over of graduates into an increasing variety of sites and sub-disciplines. Another is the change from a science push to a demand-pull. With an increasingly educated population, the public awareness and concern with the consequences of science and technology grew, and together with tighter economic conditions and a general demand for results, the pressure was on traditional science to respond.

Gibbons et al. also describe an internal shift in science; whereas modern science in the beginning was looking for ”first principles” it is now looking more to understand phenomena and processes, using empirical methods rather than mathematic models. As the disciplinary based mode 1 failed to respond to wider societal and cognitive pressures, a new mode of knowledge production emerged. Finally, new information and communication technologies allow for another way of working, where the sites of knowledge production are interacting across institutional and disciplinary boundaries.

All together, this has according to Gibbons et al. resulted in a socially distributed knowledge production system, where scientists from a variety of backgrounds work together on specific problems and with a focus that has turned towards the world outside academia. In Mode 2, knowledge production is based on the context of application; it is transdisciplinary and heterogeneous, it is organised in flat and transient ways, it is extrovert and more socially accountable with societal criteria for relevance and quality. (Gibbons et al., 1994) The differences in practice between Mode 1 and Mode 2 are summarised in table 1 below.

Table 1.

Mode 1	**Mode 2**
Problems are set and solved within an academic context	Knowledge is carried out in the context of application
Disciplinary	Transdisciplinary
Homogeneity	Heterogeneity
Hierarchical and stable	Heterarchical and Transient
Internal quality criteria, peer review	Socially Accountable, wider quality criteria

Gibbons et al. gave with their book a powerful analysis of a number of trends occurring in the production of knowledge. However, their claim that these trends constitute a new mode of knowledge production that exists parallel to the traditional Mode 1 was contested by Peter Weingart in the article "Old Wine in New Bottles" where he criticizes their description for being one not of actual changes as much as ideas of a more politically correct science. He points to the lack of empirical accords and claims the characteristics found in Mode 2 are limited to fields that are particularly exposed for public interest and concern, such as environment, health and information technologies and that the phenomena remain on the surface and cannot be generalized to concern science as a whole. Weingart sees the Mode 2 as "a normative program rather than an empirical analysis". (Weingart, 1997, p. 608) He does not contest the heterogeneity and organisational diversity described in Mode 2, but points out that this is not a new development. Instead, governmental and industrial research has a long-standing history in Europe and universities have never been alone in knowledge production. He argues that the development in recent years has rather been in opposite direction, with industry increasingly looking for cooperation with universities to achieve greater flexibility, instead of having its own research facilities. The specialisation and recombination into sub-fields shows the expanding role of science in ever more activities and is an ongoing process that does not as such influence the way knowledge is produced.

What Weingart finds interesting is the coupling of science and politics, where various stakeholders form organisations to do research. What is new is not the type knowledge production, which takes place much the same way as always, but how science is integrated into politics, and scientific knowledge informs and stimulates political discussions and decisions. (Idem. pp. 594-599)

Instead of the development of a new and distinct form of knowledge production, Weingart sees two main processes running parallel to each other. On the one hand is a politicisation of science, where actors from different policy cultures, bureaucratic, civic and economic, use scientific knowledge to represent their interests, pushing the field further and debating scientific knowledge even before the scientists themselves have reached agreement. On the other hand is a scientification of politics where systematic and certified knowledge is central to decision making in ever more fields and activities. These two processes are augmented by a third process, of media attention to politically sensitive scientific themes leading to increased public attention and more political focus on science. (Idem. pp. 605-608)

The processes described by Weingart reflect the distinction between science policy and politics for science, as well as the developments described above. But even if one accepts his criticism with regard to the analysis and descriptive value of Mode 2, the theory still has been influential as a normative model in development-oriented research. K Narayanan Nair and Vineetha Menon (2002) argue that significant contributions to demand-led research can be made by the recognition and mainstreaming of the Mode 2. Accepting it as a normative concept, a model rather than a descriptive analysis is necessary to place it onto a development context, where there is a lacking supply of scientific capacity and a large part of the population is uneducated and unaware of opportunities and threats in S&T.

Johann Mouton[7] points out, however, that it is important to consider the five main propositions of the Mode 2 thesis as a coherent set; a shift towards the context of application, transdisciplinarity, distributive knowledge, heterogeneous skills and broad sets of quality criteria. He finds that people tend to consider the five characteristics separately, and if one of them correlates with developments found in their context, they claim to have a shift to Mode 2 and forget about the other four. "Everyone who thinks there is a shift in their country to more transdisciplinary research now say there is a shift of mode … that is not what Gibbons et al. said. So unless all five conditions are in place you don't really have anything remotely like what they are describing." (Mouton, 2004)

2.2.1. Placing the characteristics of Mode 2 in the context of development

The first characteristic of Mode 2 is that knowledge is generated within the context of application, this means the total environment in which problems arise and ways to solve them are found and disseminated. This problem-based production of knowledge tries to find solutions to concrete needs and particular applications, and solving them through the involvement of the various stakeholders themselves. Gibbons et al speak of "socially distributed knowledge" as the demand for knowledge comes from society in general but also commercial interests, organisations, interest groups and individuals seek expert advice and support for their needs. (Gibbons et al. 1994, p. 4).

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As the shortcomings of technology transfer were increasingly realised, the emphasis on societal needs and interaction between the demand and supply of research has become more and more important in development-oriented research. Research that is sensitive to local contexts and ensures the involvement of users in priority setting as well as implementation will be better equipped to produce relevant and useful solutions that are sustainable because of a sense of ownership by the users involved. To realise user involvement is, however, difficult. In her study of stakeholder participation in biotechnology projects in India, Lotte Asfeld showed that although everyone might agree on the value of farmers' involvement, it was impossible to have a real dialogue between the farmers and the biotech researchers, as there are limits to how much the farmers can know about biotechnology. The farmers could participate more actively in other parts of the project that were less technologically advanced, such as product testing. She finds that the type of technology in question much defines who can participate and at what level. (Asfeld, 2001, pp. 73-78)

The level of user involvement might change within a research process and it might be more fruitful in some areas than others. The assumption that research carried out in the context of application will be more sensitive to the needs of the poor through the involvement of the users is not always valid. Mechanisms for demand articulation must be constructed that are responding to the context, and the direct involvement of users might not always be the relevant response.

Gibbons et al argue that when knowledge is produced in the context of application in Mode 2, it is this context and not their disciplinary backgrounds that structure the work of scientists. It goes further than multidisciplinary activities where a common theme is worked on from different disciplinary perspectives. Mode 2 is transdisciplinary, defined as "knowledge which emerges from a particular *context of application* with its own distinct theoretical structures, research methods and modes of practice, but which may not be locatable on the prevailing disciplinary map". (Gibbons et al., 1994, p. 168) So different theoretical and practical perspectives are brought together to solve problems without necessarily using or contributing to a particular discipline and this exit from research within disciplinary boundaries opened S&T to indigenous knowledge and participation of non-professionals in the research process. Weingart criticises the transdisciplinarity of Gibbons et al. for being a surface phenomena that can be found in research formulations at the level of program funding, while the actual research takes place in disciplinary or multidisciplinary forms. (Weingart, 1996, p. 596-598)

It has been argued that the division into a disciplinary Mode 1 and a transdisciplinary Mode 2 has been used to describe the opposite poles in a conflict between two ideologies for the control of development-oriented research. (Box, 2001, p. 17) Should it be based on technology transfer and large-scale formal science, like the green revolution, or should it be based on indigenous knowledge, locally based research and user involvement as argued for by Chambers et al. in "Farmer First" from 1989. Box proposes instead a middle ground, a Mode 3, where disciplinary as well as broader approaches are seen as complementary, where knowledge networking provides an alternative to the divide between traditional disciplinary and transdisciplinary approaches and where the linkages between the various participants is the important factor. (Idem. p. 19)

A third characteristic of Mode 2 is heterogeneity; it recognises the existence of multiple sites of knowledge production that are increasingly linked together as a result of information and communication technologies that allow for unlimited and instant interaction. Specialisation and recombination move knowledge production away from traditional disciplinary boxes and scientists move in and out of a broad spectre of transient organisations. New and changing compositions of people are involved in problem solving, with horizontal exchanges of information and without the hierarchical structure of Mode 1. (Gibbons et al., 1994, p. 6)

The distributive nature of knowledge production described in Mode 2, and its recognition of knowledge stemming from other sources than the public science establishment, is important to capture indigenous knowledge as well as contributions from the private and civil sectors in developing countries. However, the distributive aspect of Mode 2 assumes the presence of a large epistemic community and a well-developed infrastructure. Johann Mouton (2004) argues that in the dense networks of institutions, laboratories, organisations, private and public facilities, NGOs and consultancies demands emerge in democratic and participatory settings. This does not apply to the situation in developing countries, with large inequality in terms of status, economy and culture between the knowledge producer and user, where there is less density of networks of institutions, interacting networks or civil society. In this situation, demands do not emerge, but have to be stimulated and articulated.

On the one hand there must be the development of stable infrastructure and scientific capabilities, and on the other hand, to make science and technology sensitive to societal needs, there needs to be a stimulation or creation of demand. Mouton points out that a distributive system of knowledge productions does not necessarily mean that the knowledge produced favours or takes into account the needs of poor. Instead, in the context of South Africa, he finds that the shift tends towards the poles of contract and consultancy type research, rather than development and community based research. He argues that the beneficiaries of science are increasingly those who can pay for it, mainly business, industry and government, while there must be structural conditions in place, such as a strong NGO culture or community based funding if civil society is to benefit. (Mouton, 2004)

A main characteristic of the Mode 2 type of knowledge production in answering to the needs of poor is its focus on social accountability. Gibbons et al. argue that the increased public concern and interest in the results of science have increased the focus on social accountability of the whole process – from identification of problems to diffusion of results. Furthermore, they argue that by working in the context of application, scientists become more sensitive to the needs for and impacts of science. As a result, in Mode 2 there is an inbuilt awareness of this as part of the context. With a broader accountability there is a wider set of criteria to assess the quality of work. Research results in Mode 1 answer to peer review and disciplinary control, but in Mode 2 further criteria, such as social and economic sustainability of the solutions are considered. (Gibbons et al., 1994, pp. 7-8)

With a transdisciplinary and transient way of working, Mode 2 is criticised for its lack of tangible assessment methods and it can be questioned whether results in Mode 2 will be considered to be of less value than in Mode 1. Instead of solving socially relevant problems in developing countries, and putting the needs of poor on the scientific agenda, the lack of recognised codified mechanisms for quality assessment in Mode 2 might mean that less importance is given to the results, quite contrary to the intentions of developmental interests. This would also not contribute in positive direction to the recognition of scientists working in these fields. The approach suggested by Louk Box, for a mode 3 where knowledge networking, allows instead a more flexible approach, where disciplinary research and quality assessment are viewed as complementary, and not opposite to transdisciplinary methods and a broader set of quality criteria based on the context of application. (Box, 2001)

At the beginning of the chapter, the distinction between science policy and politics for science was made, the establishment and use of science on the one hand, and the orientation of science on the other. Weingart describes the changes in S&T as based on the processes of scientification of politics and politicisation of science, these are processes that needs to be stimulated for S&T to respond to the needs of developing countries, based on the particular context and accommodating the articulation of a variety of needs. In presentations and discussions at the Maastricht 2001 conference, Demanding Innovation – Articulating Policies for Demand-led Research Capacity Building, several issues were pointed out as important for science and technology to contribute to a sustainable development. Key concepts such as context sensitivity, local orientation and stakeholder participation found their reflection in the characteristics of Mode 2. But even though Mode 2 is user oriented, it does not indicate whose needs it is oriented towards and as a distinct and ideal typical form of knowledge production system it may not be a functional concept for a pro-poor development-oriented science policy.

Even if Mode 2 is considered to be of a more normative than descriptive value, it is still based on the analysis made by Gibbons et al. of the situation and trends found in developed countries, with a large supply and strong demands to S&T. As an example for science policy orientation, Mode 2 carries in-built assumptions as to what are causes and effects of these trends. Gibbons et al. found that increased public demand and context-based research has lead to an inbuilt awareness of social accountability as one of the characteristics of Mode 2. But it cannot be assumed by organising knowledge production in heterogeneous and transient ways, which are other characteristics of Mode 2 that S&T will cater to the needs of poor. It might even have opposite effects as argued by Johann Mouton above. Mode 2 emphasises the interaction between supply and demand, but for this to benefit the poor, it requires that there are mechanisms present to articulate their needs.

In the following chapter I will turn to three examples of knowledge production placed outside the traditional frame of academic institutions and aimed at research and technology development to benefit rural poor in India. I will take a closer look at the characteristics of Mode 1 and Mode 2, placed in the context of development.

3. Empirical Cases

Looking to knowledge production in the south, India makes a particular case with a strong public S&T establishment, but also an active involvement from the private sector and civil society. Furthermore, there has been done much research on the country, with available data and case studies to draw on, and where among one can find examples of research and technology development that may suggest the direction for a change in research agenda. Two of my examples of needs articulation below are based on case studies, the one of innovation lead by a civil society organisation and the other of innovation facilitated by a civil society organisation. The third case is an example of needs articulation in a public-private partnership project and is based on information and interviews with key project developers. The three are examples of very different approaches to technology development based on the context and needs of the poor rural population in India. Before describing the cases in more detail, I will briefly present the Indian context with regard to the institutional landscape and the developments in S&T policy.

3.1 Science and technology policy in the Indian Context.

India is a federal republic of 28 states with largely different natural, economic, social and political conditions. The country has a large state-governed university system, a large network of governmental research institutes and a strong reputation in high-tech fields. With a population of more than 1 billion, out of which 25% live below the poverty line, and 60% work in agriculture as small scale farmers, and with environmental threats like soil erosion and water pollution from pesticides, there are those that demand a change of priorities in its science and technology policy.

Indian S&T policy is based on the objective of economic growth and technological self-reliance and is part of the overall five-year plans. The policy environment has changed over the nearly 60 years that have passed since India became independent in 1947, and this is reflected in policy changes that can be paralleled with the previous chapter. In the first period much effort were concentrated on the creation of S&T infrastructure, including an administrative apparatus with the Department of Science and Technology (DST) and the Department of Scientific and Industrial Research (DSIR). In the 50s and 60s the Indian Institutes of Technology (IITs) were established to become centres of excellence in engineering, technology and science with a large degree of autonomy. A network of laboratories was established under the umbrella of the Council for Scientific and Industrial Research (CSIR), each focusing on a particular field. These developments reflect the strong belief in the possibilities offered through science and technology as manifested in the Scientific Policy Resolution passed by the Indian Parliament in 1958, which emphasised the responsibility of the government for basic, applied and educational science. (Idem. p. 224)

The 1970s saw an increased questioning of the role of S&T, with issues like environmentalism appearing on the international agenda and at the end of the decade, India saw an upsurge of civil society initiatives that focused on a more social agenda, such as the Centre of Sciences for Villages (CSV) established in 1978. (Prasad, 2004, p. 57) With dependency theory questioning the transfer of technology from developed countries, the Technology Policy Statement of 1983 focused on the use of national resources and traditional skills and capabilities, and the development of own technology as well as adaptation of appropriate technology according to national priorities. No support mechanisms were, however, put in place to abet such breakthroughs and Indian technological invention has been criticised as “import substitution on all levels including the idea, need, market, development and sale.” (Idem. p. 72)

Like western governments had emphasised closer links between universities and industry in the 1980s, there were similar moves to make a new technology policy in India in 1993. This included a focus on increased quantity as well as quality of scientists; university – industry linkages and development of consortia involving academic institutions, laboratories, ministerial departments and the user industry; goal oriented programmes and mobility of scientists. The draft proposals were, however, abandoned and the science establishments remained isolated. It has been claimed that much of the research findings in the CSIR system remained unutilised due to the lack of interaction with industry. (Mani, 2002, p. 239) The CSIR White Paper from 1996, “Vision and Strategy” reflects the demands for more market orientation through increased interaction with and funding from industry, and focus on development of exclusive and globally competitive technology.

Sunil Mani argues that current Indian policy was designed in the draft of the ninth Plan document for the five-year period from 1997 to 2002. It focuses on the need to increase the number of skilled people and the need to improve the S&T infrastructure. The policy includes the need for linkages between industry and universities and calls for the involvement of industry in decision-making bodies of R&D institutions, to have their demands heard. Industry is also asked to identify its needs and contribute financially to research on relevant issues. The policy focuses on competitive strengths and establishes atomic energy and space as strategic sectors, while also agriculture is recognised as a field where technology can have considerable impact. Although links with industry are promoted, the government is still strongly supporting the public scientific establishment as the primary source of knowledge. (Idem. p. 227)

India has a large formal establishment in agricultural research with institutes and labs under the CSIR system and the Indian Council for Agricultural Research (ICAR), counting 46 Central Research Institutes and 27 national research centres. Several authors have argued that Indian science still follows conventional linear understanding with public scientific bodies as the primary source of knowledge. (Prasad, 2004; Clark et al., 2002) The institutions are organised hierarchically along disciplinary lines, information and resources flow from top to bottom and quality is ensured through peer review. In this situation civil society initiatives are placed at the very bottom, as extension organisations that can take care of the dissemination of results to those at the end of the line, the farmers. There is little recognition of demands coming from civil society reflecting the needs of poor farmers.

However, there are a growing number of players on the scene, such as the Council for Advancement of Peoples Action for Rural Technologies (CAPART) and a large number of NGOs that represent civil society. Prasad traces the background of larger civil society initiatives in agriculture, on behalf of the poor, to 1934 and to Gandhi and the All India Village Industries Association (AIVIA) The association aimed at articulating the need for a different science for the poor with a broad basis of stakeholders involved and a focus on how to make the most out of the available resources, like using all parts of plants for food as well as fodder and other products. In the late 1970s a number of initiatives and organisations developed to promote the pro-poor focus. In the 1990s a number of different initiatives have addressed the problems of small-scale farmers to cope with the results of the wave of liberalisation in the 1980s and the associated economic reforms since 1991. (Prasad, 2004, p.

57) The high number of small farmer suicides in southern India shows the necessity to articulate their needs.

The three following cases show different approaches to how science and technology can be put to use in response to the needs of poor. They are all set outside the traditional Indian S&T establishment and are selected with a view to the variety in ways they seek to ensure the articulation of a broad set of needs in S&T development. The first case, of the Murugappa Chettiar Research Centre (MCRC) is an example of civil society going further than placing demands to the formal science establishment. MCRC is a non governmental organisation (NGO) that itself carries out research and development to meet the needs of rural poor. The second case is also of a NGO based in India, International Development Enterprises India. This development organisation does not carry out research itself, but acts instead as a broker between different needs and interests and the available expertise and capacities, establishing a network of expertise, demands and supply. The third case is of a project in which a multinational seed company seeks to make advanced genetic plant technology available to poor farmers through a partnership with public institutions and interests. In this chapter I will present the context and the approach taken to set and solve problems in each case, before in the following chapter, I will critique the cases in relation to the Mode1 and Mode 2 distinction and the social constructivist approach of SCOT.

3.2. Shri AMM Murugappa Chettiar Research Centre (MCRC)

The Shri AMM Murugappa Chettiar Research Centre at Chennai was established in 1973 as the private research centre of the Murugappa Group, a large corporate business group dealing in as diverse areas as engineering, farm inputs, plantations, sugar, bio-products, chemicals and financial services. Since 1976 MCRC has developed into an autonomous research centre, as a non-governmental civil society initiative engaged in research for the rural development sector as well as for the industrial sectors. The centre includes people from a variety of disciplinary backgrounds, from molecular biology to the social sciences, as well as amateurs. It is registered under the Societies Registration Act and is recognised by the department of Scientific and Industrial Research, Government of India. Research activities focus on the sustainable and environmentally sound use of natural resources; main areas of research concern the application of science and technology for problem solving in the areas of energy and resource consumption and the development of technologies for application in rural areas by the local population.

A major outcome of the work at MCRC is the development of Spirulina Algae as a nutritional supplement, based on research initiated in 1978. Today the Murugappa Group has the largest plant for manufacturing Spirulina in India, but due to its commercial value it has also become a means for the empowerment of rural women by training them in growing the algae in their backyards on a commercial scale. Other activities range from organic farming and eco-friendly paper manufacturing to wasteland management. The centre organises workshops and training programmes to introduce technologies to NGOs and it supports and encourages villages in following self-help schemes.

The case study of Shambu Prasad “The innovation trajectory of Spirulina algal technology” (2004) describes the work of MCRC on the Spirulina algae and discusses the role of civil society organisations in innovation processes. The study is presented as an unusual case of an organisation that is involved in all aspects of innovation.

3.2.1 The Spirulina Project

Spirulina Plankton is blue-green vegetable micro-algae originally found in alkaline lakes in Africa and Mexico. Because of its valuable nutritional qualities, Spirulina cultivation is today becoming a worldwide phenomenon. It contains 71% protein, which is the highest amount of protein provided by any natural source, and the yield is the highest compared to other protein yielding crops. The alga is rich in vitamins and minerals and grows in dry areas with tropical or sub tropical climate. It has wide application, from food supplement and use in healthcare and medicine, to fish feed, as a colouring agent or in cosmetics. (Mounnissamy, 2002) Much of the research done on Spirulina is credited to researchers in India, where it started out as a large-scale governmental initiative, but with the Murugappa Chettiar Research Centre doing much of the work.

MCRC focused its algal work on possible uses as food rather than animal feed or fertilisation. It managed to isolate the blue-green Spirulina algae and cultivate them for growing through basic and field-based projects. The scientific work is explained in the case study of Prasad. MCRC saw the potential of the algae in solving problems of malnutrition because of its high nutritional value and its high output. MCRC focused on using cheap raw materials and on designing the technology to suit decentralised, small-scale production in rural areas, instead of capital-intensive production. MCRC aimed at a technology that would be labour intensive and could be used by unskilled labour. This set MCRC apart from the general practice of Indian scientific establishments. (Prasad, 2004, p. 62) Thus the focus was based on an understanding of what would be a socially relevant technology designed to suit local conditions, with low costs and labour intensive methods.

From the mid 1980s, cooperation was established with companies and NGOs to commercialise the technology and the first production plant was established. Later, MCRC did large scale testing of the nutritional potential of Spirulina (1990), in cooperation with the Indian government and other research institutes. It hosted a national symposium on the possibilities of algal technology (1991), showing not only the interest and ability to cooperate with other big interest, but also the willingness to share findings and ideas. Meanwhile, the work gave MCRC access to the medical community. A large-scale nutrition test, involving 5000 pre-school children in the Pudukkottai district required institutional innovations in MCRC to cooperate with many actors, from research institutions, local health agencies and schools.

However, next to large-scale testing and commercial development, MCRC worked on adapting the technology to extend it to new social groups. Test trials were carried out in 1992 using mud pots, to teach village women to use the technology. By developing the technology to suit the village women, MCRC aimed at supporting nutritional self-sufficiency. In other cases MCRC did not work directly with communities, but provided the algae culture and cooperated with other organisations on the distribution. In this way it had access to new networks and resources to market the algae. Prasad argues that this strategic shift from a commercial to a social focus is part of a rural client focus inherent to the organisation and setting it apart from the activities of formal scientific establishments. (Idem. p. 63) The demand for a socially responsible science is at the basis of the research culture of the organisation.

After 1997 MCRC stopped further research on the Spirulina algae as the technology had been put into use. Although the research centre continued to provide training to NGOs, further development work was left to extension organisations supporting local production. These organisations have continued the work, showing creativity in algae cultivation through different approaches, in how the tanks are constructed, how the produce is processed, what products are made and how these are marketed and distributed. (Idem. p. 64) Through these organisations there is a continued innovation in production and in products taking place, adapting the technology to suit local conditions, resources and markets.

3.2.2. The MCRC Approach

The research culture at MCRC as described by Prasad is based on a philosophy of work that "calls for the articulation and definition of an engineering problem based on a keen context sensitivity to the social issues of a developing country" (Idem. p. 66). The identification of research problems at MCRC is based on advanced technological insights and analysis combined with a strong social concern, a focus on resource-conservation and an integrated approach. From this starting point the research process within the MCRC is described as an open and ongoing learning process that valued failure as a part of learning and recognised the process itself and not only its outcome. Multidisciplinary teams were used to view issues from different perspectives, and encouraged scientists to cross the disciplinary boundaries by participating in other activities like marketing or training. MCRC carried out basic as well as applied research and it was involved in commercialisation and diffusion activities with focus on the applicability in the context of the rural poor. Furthermore, learning across activities allowed previous experiences from research activities in local communities and from training courses for women to make important input to the Spirulina project.

In the Spirulina project scientists at MCRC saw the possibility of applying algae technology on the problem of malnutrition and further to offer a source of income and employment for the rural poor population. Partnerships with other NGOs brought in new agendas, along with new skills and resources, and was seen as critical to the further dissemination and development of the technology. Carrying out activities in direct contact and cooperation with the local communities allowed scientists at MCRC to better realise and respond to local needs, the close contact with the realities in the field facilitated a better problem definition and the local activities gave direct input to the research process.

MCRC saw the problem-solving opportunities that Spirulina technology could offer and worked to ensure its availability and applicability for local conditions. It can be argued that rather than responding to a need, MCRC responded to an opportunity and found a way to adapt this to the needs of the rural population. This way of forming the technology focus differs from the approach chosen by the second case, also of a non-governmental organisation, International Development Enterprises, IDE. This organisation carries out, as a starting point, extensive needs assessments among farmers, before identifying the relevant technological constraint. IDE also takes a different role from the central position played by MCRC in all activities, whether in identifying needs and adapting technology to local conditions and skills, or in disseminating technology and training of village women. Instead, IDE acts as broker, by facilitating the involvement of farmers, research institutes and organisations to carry out the various activities.

3.3. International Development Enterprises

International Development Enterprises (IDE) is a non-profit, international non-governmental organisation that focuses its activities on poverty alleviation in rural areas through developing technologies that are designed and engineered from the poor farmer's perspective. It was established in 1973 and is today active in Africa and in South and East Asia. It began activities in India in 1990, and in 2001 IDE India changed from being a representative office to a registered non-profit organisation and was thereby established as an autonomous organisation with its own Board of Directors and Executive Director.

The organisation bases its approach on the view that access to appropriate technology for developing countries is not a question of simply transferring the technologies, as it was proposed by the modernisation theory, or that appropriate technology is a question of inventing intermediary technologies in order for developing world to take the leap and catch up with the west, as Schumacher had suggested. (Clark et al., 2003, p. 1846) Instead IDE see it as a question of developing local production and distribution in a long-term perspective. This means generating knowledge of the local context and needs as a starting point and to develop or reengineer technologies that meet these needs. Based on the local context, IDE focuses on the development of capacities to carry out the technical development and testing, the logistics of marketing and distribution, as well as the relations between the different actors involved in this process.

IDE works with small-scale farmers to identify needs and possible technological solutions to improve their agricultural production and help them participate in markets. It involves small and local enterprises to enable them to produce and market the technology at affordable prices, and traders to ensure distribution of technology and farmer's access to markets. It works with research institutes to find the best technological solutions to the needs of the farmers. Finally, it facilitates the development of links and interaction between the different actors to ensure an ongoing process of research and innovation, involving small farmers, producers, researchers, traders and other relevant actors. The aim of this approach is the development of a knowledge network of producers and users, which would be self-sustainable and evolve independently without the continued involvement of IDE.

I base the case of IDE on the review of Clark et al. “Research as Capacity Building: The Case of an NGO Facilitated Post-Harvest Innovation System for the Himalayan Hills” (2003), which describe and discuss the IDE approach from an innovation systems perspective.

3.3.1 IDE Activities

IDE India’s main programme activities concern the dissemination of treadle pumps and drip irrigation. The treadle pump initiative started in Bangladesh in 1984 and attacked the problem of limited access to irrigation water. Floods had threatened food security and water for irrigation was needed; existing water pumps were too expensive for the poor farmers and wells were too far away. The identified need among small-scale farmers was a manual pump that would be affordable and functional. IDE searched for possible technologies and even though the organisation initially had found a “rower pump” to be most suitable, they chose the “treadle pump” as this was preferred by the farmers themselves. The treadle pump is made up of two metal cylinders with pistons that are operated by stepping on treadles of bamboo or other local material. All parts can be manufactured locally and is easily maintained. Selecting the technology was in this case a choice between two existing technologies and the main work was to develop a local supply chain to make the technology available, affordable and sustainable. IDE promoted local production and established an association for the local producers while at the same time helping more to get into production. IDE marketed the product through buying from these local producers and thereby also controlling the quality, and then put into place a network of local traders. Promotion activities spread the news to the farmers and helped the sales. After the production and sales stabilised, IDE expanded the initiative to India. The self-sufficient network now includes manufacturers, distributors, dealers, NGOs, mechanics and users and IDE India is introducing the technology to new areas. (Idem. pp. 1849-1850)

The IDE India post-harvest project, which Clark et al. review in their case study, was part of the Crop Post-Harvest program of DFID, the UK Department for International Development and as such limited from the beginning to focus on post harvest technologies. However, the application procedures of the programme also requested specification of the technology to be developed and what initially was meant as an open-ended approach with technology identification as part of the project, was limited in advance to be focused on post-harvest handling, packaging and storage. Describing this initial process, Clark et al. write that this ”reflected the norms of a donor research assistance program that, although evolving, was clearly coming from a linear, ‘transfer of technology’ way of thinking” (Idem. p. 1852).

From this basis IDE carried out a needs assessment study, and with the help of NGOs and individual actors interviews were made with a wide variety of stakeholders; small-scale farmers, actors on vegetable markets, box traders, transporters and local NGOs. Through identification of such a variety of interests and needs, IDE could establish an understanding of the whole supply chain and identify what to focus attention on, in this case tomato packaging technology. Tomato is a much grown crop among small farmers and there was the need for an alternative to wooden tomato boxes as the production of these had caused overexploitation of trees and put pressure on the environment. While checking out the possible supply chains of packaging and how to reach out to the farmers, IDE looked around for technological solutions and ended up with the choice of cardboard boxes. From here the search continued for the appropriate technology and expertise, which was found with an engineer working on the subject. Through the institute of this engineer, a connection was made to a commercial cardboard manufacturer with research and testing facilities. In this way needs were identified, a technological solution found, and links made with engineering, research and manufacturing expertise.

IDE did not itself have the knowledge or resources needed, but through linking up, the stakeholders could all satisfy their different needs; tomato farmers needed an alternative to the wooden boxes; the engineer and his institute had searched for a packaging technology that would reduce fruit damage under transport; the latter had links with box manufacturers and IDE had contacts with a organisation that could help in the field testing of the technology. IDE had established links with this local NGO during the initial needs identification, as well as with auction traders and transporters, and had through them access to networks of farmers with whom testing of the boxes and transportation could be done. Through several trials with farmers and marketing systems various adjustments were made, while at the same time relationships between manufacturers, box traders, transporters and farmers were established. (Idem. pp. 1851-1856)

3.3.2. The IDE Approach

The case of IDE India reflects an open-ended approach, where an initial process of broad participation leads to the problem formulation and where the organisation facilitates the articulation of needs of a broad range of stakeholders according to the context of application. In the case of the treadle pump, the organisation responded to the needs of farmers for a technology that would be affordable, and costs to be regained within one cropping season, It would be flexible to suit different farmers' needs and simple enough to operate and maintain.

The organisation uses networks of partners in the research, production and distribution of the technology, to establish a supply system that is using and developing local capacities and meet the demand of small-scale farmers. In the case of the tomato boxes, partnerships were built with local organisations, farmers, traders and transporters to identify their needs and thereby ensure the functionality and accept of the product. By linking up with local NGOs when introducing new programmes or technologies in new regions IDE profits from the relations that have already been established and can tap into the network and connections of the local organisation. In the case of the tomato boxes, Clark et al. also point out the importance of individual actors, like the agricultural engineer working on cardboard technology. (Idem. p.1859)

IDE builds its activities on the facilitation of relationships between different actors. The facilitating role means building trust and finding the right organisations and individuals to participate, ensuring the complementarity of skills but also the shared values and perspectives. One basic perspective in the work of IDE is the pro-poor focus, this gives direction to the institutional build-up as only technologies that are relevant to the poor are considered and it is only relevant to involve organisations that are dealing with or care for the poor. Another important aspect of developing the network is to understand the different interests and motivations of the various actors involved and to help them see how they can meet their own demands through the cooperation within a systemic process. Rewards can be economic through increased production for farmers or new production for local entrepreneurs. Individual recognition of the scientists or new contacts and credibility for local NGOs are motivating incentives that ensure that actors are comfortable with their role and opportunities in the network.

The IDE model leaves none of the involved partners unaffected as new relationships are formed between organisations and individuals. In the case of the tomato boxes, contacts were made between the scientist at the research institute and small-scale farmers in local NGOs and opening their eyes for the mutual benefits as previously unarticulated needs of the farmers were met with the expertise previously locked up in the institute. As the process of technological development, testing, production and marketing continues back and forth, the involved actors and their roles change and not all actors are relevant in all activities. Important in the IDE approach is the recognition of the different and appropriate roles of the various actors, that all actors have clearly defined roles, that these can be played effectively and that there is accountability towards other partners. While the participation of farmers was important in choosing the right pump technology, it was less so in finding the right cardboard technology and while the involvement of the engineer was important in the first trials of the tomato boxes, he was not involved in the marketing activities. (Idem. pp. 1851-1858)

The aim of IDE is the establishment of a network, which is sustainable on its own and can continue to evolve and link science and technology development to the needs of the poor. The proof of success is when IDE itself as facilitator becomes superfluous. In the following case, a private company acts as initiator and itself one of the partners in a crop improvement research project. Stronger than what was the case with the IDE network the actors involved in the established partnership below are tied together, by identifying the common benefits of cooperation and creating a win-win situation.

3.4. Project on Insect Management in Cabbage and Cauliflower in India

The third case concerns the development of a project to develop a pest resistant plant variety for the use of small-scale farmers in India. As the project still is its initial phase and waiting for approval by the involved actors, their names and details on the nature of the project will be left out. The case focuses on the approach that is proposed in the project as a response to needs of poor farmers in India, while at the same time making use of available expertise and intellectual property rights, in a public-private partnership.

The background problem, which the project addresses, is the excessive use of insecticides in India. Small-scale farmers are using large quantities of chemicals to reduce crop damage by pests. This is threatening the health of farmers and consumers, as well as posing risks for the environment. As insects develop resistance to the chemicals in use, the solution has mainly been to increase the use or to introduce new insecticides. One particularly destructive insect is the Diamondback moth, which attacks cabbage and cauliflower and has developed resistance to most insecticides. The project seeks to find a sustainable solution to this problem through the development of genetically modified plant varieties in combination with an integrated insect management using biological and chemical methods.

With the introduction of intellectual property protection of modern plant breeding technologies by patenting, the access to modern technology has been limited for small-scale farmers. While industry has consolidated and gone global, the free flow of genetic material and know-how from the public sector has stopped and instead, plant research has become a more competitive process, leaving poor farmers wanting. Breaking away from this trend, the project aims to make locally adapted varieties available to farmers, free of licence, with the objective of reducing the use of chemical pesticides, thus reducing crop production costs and ultimately reducing poverty in the developing world.

The project was initiated by an International research centre working in the field of sustainable resource management and with the invited participation of a multinational seed company. It suited the company well to be an invited partner and to remain in the background but as the project came to near standstill, the company decided to become more active with the intention to deliver the plant material; there should be others to work on the front lines and have major links to local organisations.

3.4.1. Approach of the hybrid plant Project

The approach suggested to reach the aims of the project is one of partnership between the public and private sectors; a partner consortium is formed and costs are shared between the company and public sponsors. While the company will be involved in all phases of the project, it plays different roles along the way. In the different steps of the project, all major actors have a role with one of the partners having the first responsibility for a block of activities. The company has the most prominent role in the development of material, making sure that it is in accordance with global standards, i.e. stable and safe. At the same time another consortium partner will have the responsibility to look into economic impacts in the region; yet another partner might be looking how to communicate the technology to the region, and one partner for stewardship and training of local farmers in the use of the product. So some partner will lead one bloc of activities and on top of that there is a management to coordinate the different activities. In this way it will also be easier to allocate public funds; individual consortium partners can be paid by their national government or international aid agencies like the World Bank. Essential in all this is to create commitment and ownership of international and especially local stakeholders.

For the company, the approach of this project is unique in that it is intending to develop the complete product together with different partners and there are several questions that the company has to consider before entering into partnerships. The company must be sure about the quality and effects of the technology it gives away; it must also be sure that the partners know what they receive and are able to handle it. In all cases it is difficult to decide whether a technology can be given away for free and how this can be done.

The technology to be given away in this project is transgenic material where the end product still has to be developed and officially registered, and if this is done in the wrong way, the final link will be made to the company that delivered so called “red technology”. This means that the decision which partners to involve is very important for the company in order to prevent that it is left with the costs of defending a product it gave away for free in the event of court cases brought against it. One of the major difficulties in the project is the question of ownership of the intellectual property rights; -who can be the new owner? This is especially difficult when it concerns different genes in plant material that is given away under conditions that are acceptable to everybody involved. One condition is that it will be available to small farmers, another that it doesn’t benefit other major companies, as that would counterbalance the interests of the involved company.

To reduce the risks involved in giving away gene technology this project proposes a different approach. The company is responsible for product development and covers part of the costs, the work is done by global experts, own or external and any problems with the product become clear as early as possible, assuring that the product which is given away at the end will not create problems for the company. The company selects the best plant material, but further testing can be done by the partners, thereby ensuring capacity building and increased project ownership. If global institutes or public companies do the safety analyses, this may strengthen the acceptance of the product. Working in a consortium enables the company to anticipate problems and think of alternative solutions early in the process. Through this approach the technology may become more sustainable and help the company to deliver better products.

There are a variety of needs and interests that must be attended to when developing new plant varieties, such as the impacts on the local community and the farmers, social-ethical and social economical concerns, impacts on target and non-target organisms, impacts on the environment and on gene-flow. Particular to this project is the importance of the technology for small farmers. Next to the work related to the plant variety the project includes parallel activities on crop management; growing a variety of crops, also to attract natural enemies as well as more effective and safe use of pesticides. The company's search for partners with the right expertise on these issues, including a sensitivity to farmers needs, leads to a consortium of partners bringing all the expertise together. The project needs partners to muster enough commitment to get the work done, while keeping the group small enough to reduce bureaucracy and cost.

For the company to invest time and money in such a project it is important to have some benefits; it should be a win-win situation for all partners. For the company this means to make some profit, a good reputation in the region, or to first market a product. To make sure that all partners profit from the project the initial process of establishing a common understanding takes much time.

To get product acceptance, the project focus is broader than the local or national level. A global orientation is needed since a product that is developed for India will rapidly cross borders if it is a success. One of the responsibilities of the company is to anticipate GMO registration in other countries. For different countries there are different criteria and regional studies are therefore needed. Through a consortium it is possible to work in more countries with more institutions joining forces to do regional studies. Cooperation with and support from regional and global organisations would help the acceptance of the GMO product, and could also make it easier to raise financial support to the project. So the company deals with local government, local institutes, regional institutes but also global organisations.

Initial talks with scientists and government people in the region have served to introduce the project and link up expertise. While global organisations and local governments responded well to the project, the company fears opposition from major NGOs due to the introduction of GMOs. The plan is therefore to organise a major workshop in the region. This, however, awaits the final identification of consortium partners. The project refrains from engaging public discussion until the project idea has been completed and is established among the partners, as a loose scheme would be torn apart by strong NGOs that focus on particular issues such as the involvement of a multinational company. With a group of partners involved, the company can stay in the background, while partner organisations have the role of door openers and communicators. In the end this should lead to one consortium, one total project plan, one mission statement and one time-lime for development.

Through the establishment of a public private partnership, the above project is proposing an approach that combines a focus on the needs of small-scale farmers with the realities of the international corporate world. The company responds to the demand for new ways of insect management for small-scale farmers in India, and it suggests forming a partner consortium to ensure the sustainable development and transfer of a technological solution.

Through the partnership, the company sees the possibility to carry out a wide variety of assessment studies, ensuring that the technology is adapted to local needs, is usable and safe. Furthermore, a partnership can increase the acceptance, ownership and distribution of the final product, and it offers new ways of dealing with public funding and the ownership of intellectual property rights. In the long run it might increase the public acceptance of GMO in India and South Asia and thereby opening up the market for the corporate biotech sector.

3.5. Knowledge production through networked approaches

India has a fairly distributed system of knowledge production in the field of agriculture, with a large public S&T establishment as well as a large involvement by private and civil society actors. The empirical cases of pro poor development oriented research and development presented in the previous chapter were all initiated and organised outside the public sector and provide evidence of the diversity of approaches to knowledge production show the importance of recognising alternative contributions to development. The wide variety of approaches contains lessons for public S&T policy and development strategies.

A major feature of all the cases is the ability to attend a broad spectre of interests by means of cooperation with a wide variety of actors. In the case of MCRC this is an internal function of the organisation, with a variety of backgrounds present and where interaction and learning across project activities and disciplinary boundaries is an essential part of the organisational culture. MCRC had a variety of scientists and engineers working on the opportunities offered by the Spirulina algae to adapt it to different contexts and social groups, in cooperation with rural communities or local organisations.

In the case of IDE, the tomato box project involved a whole range of environmental, technical, economic and social aspects. The organisation facilitated the development cooperation in a knowledge network that is external to the organisation and should ultimately stand on its own.

The project on insect management looks into the possibilities of new plant varieties from the views of the genetic engineer, entomologist, small-scale farmer, consumer interests and global regulations, but it also involves training of farmers in integrated crop management, with the use of natural enemies, better growing conditions with a variety of crops and crops that can be hosts for the insects but also their natural enemies. The company is part of a consortium of partners, with clearly defined responsibilities and the development of a joint project concept and mission.

In all cases the objective is the improved economic situation of rural communities and small-scale farmers, but how the problem is identified and by whom it is articulated differs. IDE works closest to the farmers and carries out needs assessments in cooperation with local organisations to identify problems that can be targeted, solutions are sought in simple technology that can be produced locally in order to involve the community around the farmer.

The MCRC case involved more advanced technology and while local farmers or village women would not have seen the opportunities offered by the blue-green algae, the scientists at MCRC were able to combine scientific expertise with a pro-poor focus and deliver a solution that could be adapted to the individual needs in cooperation with the local women.

The third case takes a further step away where the company is approached by a development organisation to develop an advanced technological solution to insect management. The local farmers have no possibility to involve in the process of genetic engineering, in safety assessment or registration of the technology. Instead a wide spectre of expert studies will ensure the quality of the product, and that it is useful and accessible to small-scale farmers. In the end it is the farmer who decides whether the project has been successful, when deciding to buy the product or not

Within the partnerships the roles of the involved actors are changing in terms of level and type of involvement and it is important that the roles are clearly defined and that there is a balance so that the interests of all parts are served. How different the partnerships may be, they are all based on an idea of sharing of ideas with new insights and knowledge being based on the combination of a variety of viewpoints, expertise and experience.

3.5.1. From a Mode 1 and Mode 2 distinction towards a Mode 3

It can be argued that Indian science establishment share its characteristics with the knowledge production system that was built in the West after the Second World War and which Gibbons et al. have labelled Mode 1 type of knowledge production. But while some of the characteristics of the Mode 2 can be discerned in the above cases, the strict ideal type division of the Gibbons et al. Mode 1 and Mode 2 type of knowledge production does not function in explaining the alternative approaches to knowledge production that are presented. In table 2 below, the defining characteristics of the two modes are compared with the empirical cases.

Table 2.

Mode 1/ Mode 2	**MCRC**	**IDE**	**Plant project**
Academic context / context of application	The technology was developed in academic context but closeness to the field allowed scientists at MCRC to focus their work on the needs of the rural population	All research carried out in direct response to the articulated need of stakeholders	The project implements a technology developed in an academic context, but responds to particular needs in adapting and dissemination of the product
Disciplinary/ Transdisciplinary	Multidisciplinary approach to research, teams working together, includes scientists and amateurs	A variety of expertise is brought together, playing different roles in the production process, but with scientific expertise disciplinary based	Disciplinary approach to research, the consortium brings together the findings from experts in relevant fields. The project links up scientific, political and cultural expertise
Homogeneity / Heterogeneity	Within the research organisation, various teams work across projects, flexible organisation allows accommodation of problem solving	Involving a variety of actors in the process, according to the specific problem to be solved	The project proposes a new structure for bringing expertise together
Hierarchical and stable / Heterarchical and transient	The research institute forms a stable frame, within which temporary groups of scientists can work on particular problems	Heterarchical structure, involving a variety of actors, stabilising into a sustainable network	The project establishes a stable and hierarchical structure, a consortium with common statement and management structure
Internal quality criteria / wider quality criteria	Technology is tested according to scientific criteria, wider dissemination is evaluated on broader criteria, such as women empowerment,	Quality assessed based on the efficiency of solving problem and sustainability of the production network	Scientific criteria is essential to plant variety development, project success is subject to wide range of political, economic and ethical criteria

Considering the point by Mouton, previously referred to, of recognising Mode 2 as a coherent set of characteristics, it seems clear that neither of the three cases above can be fully understood through the ideal typical Mode 1 or Mode 2 by Gibbons et al. They describe instead a more complex situation, of flexible networks that link various expertise adapted to the context and demands from different stakeholders. The Mode 3, argued by Box (2001) takes the middle ground where knowledge networks include elements of both Mode 1 and Mode 2. This approach provides a better model for explaining the linkages between formal disciplinary science and expertise from farmers, tradesmen, manufacturers and NGOs and the evaluation of quality, based on scientific as well as a wider set of criteria, ensuring the relevance of the end products.

It may be fruitful to draw on the description by Peter Weingart, presented in the previous chapter, of the processes of politicisation of science and scientification of politics. The involvement of new knowledge networks such as the ones described above, that take a clear pro poor perspective in their activities, can contribute to a reorientation of science by placing the interests of poor on the research agenda and by providing ways of needs articulation, thus narrowing the distance between science and the public in developing countries. Returning quickly to the general scenario described by Arunachalam Subbiah at the beginning of the thesis, this politicisation of science could increase the "sensitivity to the needs of the poor, in terms of setting the research agenda", there is, however, still the point of "delivering the products of research towards benefiting those people". How to enable the scientification of politics in developing countries, towards making development strategies more knowledge based? I will in the following chapter discuss how the field of STS and more specifically, the constructivist approach to science and technology may provide a way forward.

The hybrid plant project, as well as the approaches of IDE and MCRC provides evidence of the diversity of approaches to research and technology development. They depart from traditional scientific, linear based projects, where public research organisations identify and conduct research and technology is transferred to end users by means of extension organisations. Based on developmental goals, the three cases show broad and active participation of diverse actors in evolving processes, embedded in the wider social, political and economic context. While the Gibbons thesis provides a set of characteristics to denote a change in knowledge production, a different conceptual framework for analysing knowledge production is presented by the social construction of technology (SCOT). The constructivist perspective emphasises the need to understand the social processes that shapes knowledge in the making and in the following chapter I will consider the features of the three cases in relation to SCOT to see whether this framework can provide a further insight of the cases and the relevance of needs articulation through stakeholder involvement.

4. The social shaping of science and technology policy

Osita Ogbu (2004) argued for the need for governments in developing countries to take the leading role as engineers of a development process based on national vision and an own S&T base. Contributions from science and technology have changed the way we live and understand society, and can have great impact on the development of society. Undoubtedly there is much to gain for developing countries from science and technology. But contrary to the scientific realism portraying science as objective and value free, and technological determinism where technology is seen as an independent factor of societal change, science, technology and society (STD) studies have shown that the way science and technology interact with society is context specific and constructed. Constructivists have shown that it is not so much science and technology that produces change in society, but rather social processes that shapes science and technology. By recognising this social shaping, contextualised knowledge about a broad range of issues becomes important in setting science policy agendas; it makes policy dialogue meaningful and stakeholder involvement crucial.

4.1. Science and technology as a social construct

The standard view of science and technology presents knowledge as discovered by scientists through established methodologies, it is seen as autonomous, separate from the political domain, as exemplified by the science push model described above. Technology develops in a linear way, following an internal technical logic independent from any external factors, and then proceeds to cause social change. The social responsibility lay with scientists and technologists. (Bijker, 2001, pp 22-23) Sally Wyatt has differentiated between technological determinism and the image of technology as neutral. In the first, technological progress equals social progress and there is no place for intervention or choice as to its direction. The latter recognises that there are no straightforward social effects, but consider this as a result of how it is put into use, and not internal to the technology itself. Thus there are a variety of issues that influence how we use technology, but the inner working and process of developing this technology is still except from social forces. (Wyatt, 1998, pp. 10-13) Contradicting the standard view, the constructivist argument is that facts and artifacts themselves are made by people and influenced by political, economic and cultural processes.

The linear view of knowledge production began to be criticised in the 1960s, as mentioned in chapter 2. Empirical science studies showed that technological developments were not necessarily based on scientific knowledge, but could come from a variety of sources, and that the process of innovation was not linear, but one of interaction back and forth between research and engineering, knowledge production and distribution, the scientist and the user. The realist and determinist view of science and technology has over the past 30 years been opposed by STS studies where a constructivist approach was developed, based on empirical research on the practices of scientists and engineers. From the 1970s, research in the sociology of scientific knowledge (SSK) argued that scientific facts are actually constructed by scientists and not discovered by using established methodologies. More interpretations of the findings are possible, and it is the social processes of negotiation and consensus building, that decides what ends up to be the accepted answer or "fact. In this perspective, the scientific controversies in the 1970s, in such fields as environment and health, were not a question of right or wrong, but a question of interpretation and social processes. In the 1980s, constructivist analysis of technology contradicted also the determinist and neutral images of technology and showed how its development is shaped by social factors in a non linear process without separate stages, and which includes and responds to its effects; technological artifacts, just as scientific facts, were socially constructed. While the traditional view left no space for choice or intervention, the constructivist view sees science and technology as value laden and intertwined with politics, shaped by its social environment and the influence and interaction of a wide range of actors, and it is necessary to look into its technical as well as social, economic and political aspects to understand this process. (Bijker, 2001, pp. 22-26)

4.1.1. Revisiting the cases

Revisiting the cases of the previous chapter through the Social Construction of Technology approach (SCOT) may be helpful in seeing how the involvement of different stakeholders have shaped the resulting technological artifacts. I will be using the SCOT approach as it has been described by Wiebe Bijker in relation to the development of the bicycle, where he shows how the same artifact was understood differently by various social groups; sports cyclists, women cyclists elderly men, and how their different interpretations stabilised in a multidirectional process of interaction, problem identification and solution. (Pinch & Bijker, 1987, pp.28-40) My cases show examples of less messy processes, where the process of stabilisation is more organised by involving different stakeholders from the beginning, to agree upon mutually acceptable solutions.

The SCOT approach takes relevant social groups as its starting point. A social group is recognised as one where all members “share the same set of meanings, attached to the specific artifact” and to be relevant, some meaning must be attached to the artifact in the first place. (Idem. p. 30) All the cases above target poor farmers but the relevance of farmer, as social group in the technology development differs. In the case of MCRC, farmers did not have the expertise to see the possibilities of Spirulina algae and could not attach any meaning to the technology at first. However, the scientists at MCRC worked close to the farmers and the meaning they attached to the technology was therefore more sensitive to their needs.

Other relevant social groups were scientists at other research institutes who had worked on the algae as animal fodder, but also the multinational pharmaceutical companies that saw the algae product as a competitor to their vitamin products and argued that it was toxic. The interaction among relevant social groups gave different meaning to the same artifact. This interpretative flexibility means also that the social groups that are involved in defining the problem influence also the choice of direction for the possible solutions. As algae cultures were introduced to local organisations and village women, they could themselves attach meaning to it, it was partly already set by MCRC, as a nutritional compound and as a way of income generation, but new aspects regarding the cultivation and end products was influenced by these new relevant social group.

In the treadle mill case of IDE, the process of identifying needs involved direct participation of farmers and the meaning they attached to the artifact was decisive. The solution was found in a simple technology that not only responded to the problem of access to water, but which also was easily understood and could be adapted and maintained by the farmers themselves. In the third case, of the hybrid plant project, the seed company was asked by a research organisation to find a solution to an identified need, through advanced genetic technology. In the planned project process that leads up to the distribution of the technology, the farmers have no direct influence on the design process before saying yes or no to the final product. For the different relevant social groups for a certain artifact different problems and solutions can thus be identified, and which may conflict with each other.

In the hybrid plant project, an identified problem was of farmers that cannot afford to buy new seed each year and rather wish to produce own seeds, the suggested solution in response to this was to develop a second open pollinated plant variety. This proposal was, however, discarded as a result of environmental concerns that the genes would then also spread into the environment, and instead other solutions to the problem must be identified.

As the interaction between different social groups proceeds, and agreements are reached on the different identified problems, the artifact stabilises, and in this process a technological frame is created which includes all the aspects that influence interaction between the groups. "Elements of technological frame include goals, key problems, problem-solving strategies, testing procedures, design methods, user's practice and the perceived substitution function of the new artifact". (Bijker, 1995, in Wyatt, 1998, p. 23) In all the cases above, the usefulness and acceptance of the final technological product is improved by involving a wide variety of stakeholders in the process of stabilisation. The needs and demands of the end-user; -the farmer, is articulated in different ways, through direct participation, by farmer organisations or NGOs, by scientists that are close to the field and sensitive to the needs and by large-scale assessment studies. However, the social groups that are involved in the process of stabilisation, or the ones that are more powerful, may agree on solutions that limit the influence of other groups. The more advanced the technology is the less is the chance of an effective direct dialogue between the engineer and the farmer.

Apart from the need of farmers, there are also a number of other social concerns that influence the process and groups that are included in the technological frame. To fight back claims from multinational companies that the algae was toxic, MCRC carried out large scale testing in cooperation with public health departments as well as village level institutions to reach closure on Spirulina as a nutritional supplement. In the tomato box case of IDE, also transporters, market agents and cardboard manufacturers were involved and environmental policies (against deforestation) and consumer interests (the box design) influenced the process before the technological artifact was stabilised. By facilitating the establishment of a self-sustaining system that supports the production and distribution of the technology, IDE is no longer needed as broker and can pull out of the activities.

In the case of the hybrid plant project, the involvement of stakeholders has been particularly stressed as important for the stabilisation of the technology. As all the three cases, this is an example of a holistic approach, whereby taking into consideration a wide number of issues, political, economic and social aspects, a strong technological frame is created. In this case this means genetic engineering, but also impact analysis on target and non-targets in the region, impacts on heath and environment, the impact on the small-scale farmer and local communities. It includes adherence to regional and global standards and regulations, political acceptance in the region and on global level and anticipation of criticism from organisations and movements that are against GMO's or multinational companies. By reaching consensus on the project among a strong network of organisations, supported by a common mission statement and a consortium structure, the technology is already stabilised within this network and cannot easily be changed.

Bijker distinguishes between a micropolitics of power, which is reflected in the negotiation of meaning during the creation of a technological frame, and a semiotic power structure, which develops as meanings are becoming fixed. The technology is part of a larger socio-technical ensemble, which may have impact on the way society develops. (Bijker, 2001, pp. 28-29) Contrary to the case of IDE, where the farmers are directly involved in the process of technology development, and therefore familiar with the working of the technology, the farmer as end-user of the technology in the hybrid plant project, is presented with a "take it or leave it choice" and the inner workings of the technology itself is closed to them. By accepting the technology, farmers can become part of the power structure surrounding the technology, with possibilities of higher yields as well as access to training programmes and expertise, but they also become dependent on buying seeds every year rather than producing themselves.

Emphasising the aspects of interpretative flexibility and stabilisation, Pinch and Bijker argue for an integrated approach to the study of science and technology, where the sociology of scientific knowledge and the sociology of technology meet. From a constructivist perspective, science and technology are both socially constructed, as is the boundary between them. The authors draw parallels between two social constructivist approaches, SCOT, described above, and the Empirical Programme of Relativism (EPOR). The EPOR approach was developed earlier, but the arguments are similar in that scientific findings can be understood and interpreted in more than one way and what ends up as the accepted answer or "truth" when closure is reached, depends on the social environment and the negotiation between its constituting social groups. Finally, Pinch and Bijker argue for the need to consider the wider context of science and technology, as it is the socio-cultural and political situation of a social group, which forms the meaning it attaches to artifacts, and different meanings constitute different lines of development. (Pinch & Bijker, 1987, pp. 40-47)

When moving to the level of science and technology policy making, this realisation underlines the importance of addressing issues in the wider political, economic and cultural environment of developing countries, and the participation of a wide spectre of social groups in setting the goals for science and technology.

4.2. A constructivist perspective on science Policy

The traditional view of science as universally true and value free and technological development as an autonomous force that changes society, left little space for political choice. A constructivist approach to science and technology exposes the interpretative flexibility of facts and artifacts and the social processes that shapes them and as Wiebe Bijker argues, this is a condition for a politicisation of science and technology, by exposing the possibility of choice. On the other hand, the approach also provides a way to understand how facts and artifacts through the process of stabilisation and closure become established in socio-technical ensembles that can be fixed and obdurate and thereby influence social development. (Bijker, 2001, pp. 27-29)

When viewing S&T as socially constructed, constructivism does not mean that scientific knowledge is irrelevant; it merely says that it is one of many kinds of expertise involved in developing it. The content of S&T is not solely a matter for scientists and engineers to develop, like the standard view of S&T suggests, exemplified by the ideal typical Mode 1 of Gibbons et al. It is neither a question of discharging scientific expertise, arguing that farmers themselves know best what they need, or as exemplified by the treatment of disciplinary research in the ideal typical Mode 2 of Gibbons et al. Instead, Bijker argues, "A constructivist view of knowledge and technology implies the existence of a variety of expertise. Different relevant social groups have their specific kinds of expertise". (Idem. pp. 30-31)

Constructivism allow for a broader view of science and technology, which recognises different types of expertise and their networked interaction, showing the importance of involving different social groups in the development process. As important as the influences of a scientific expert with his or her disciplinary background in molecular biology or sociology is the influence of other social groups that engage in political debates on S&T and bring in their expertise, whether this is global NGO's campaigning against the introduction of GMO's, or local farmer associations involved in extension activities.

Weingart described the process of scientification of politics, as a situation where policy-making becomes increasingly based on scientific knowledge, but the scientific knowledge system, as it was developed in the industrialised countries after the Second World War should also be regarded as a social construct like indigenous knowledge systems, and not more or less valid. The success of academic science may be explained by its obduracy as a socio-technical ensemble, owing to its established support among social groups, by methodologies as peer review and disciplinary hierarchy and supporting theories. This obduracy does not however mean that it should be the only source of expertise to inform politics in developing countries. As the three cases above show the need to contextualise the approaches to knowledge development and allow for a diversity of networked approaches, also science and technology policy needs to be based on a variety of expertise.

4.3. Establishing policy dialogue among Stakeholders

Ogbu points out the central role of the government in engineering a science and technology led development. He argues that the government should recognise the role of other actors, but keep a long term and broad view of development and not give in for short term, micro or sectoral interests. It should play an intermediation role in bringing the knowledge sector and the production sector together. (Ogbu, 2004) He claims that there is the need for a change of mindset, from what he calls a surrender mentality of southern governments, of dependency on and compliance with northern knowledge and institutions. To change this mindset, he called for a new leadership with confidence to argue their case independently, based on an indigenous science establishment driven by national policies and not donor-driven agendas. He argues for the need of a common vision in order to agree on research priorities and strategies; based on, and sensitive to national institutions and local conditions, and acknowledging local knowledge. In arguing for the central role played by the state in developing science and technology, he is joined by Mani who at the *Providing Demand* workshop presented a comparative case study of the manufacturing sector in Singapore and Malaysia. He stress the importance played by the government of Singapore, based on an epistemic community with a clear strategy of backing and promoting research, in developing a coherent S&T policy and concurrent evaluations of the efficacy of the policy instruments. (Mani, 2004)

Ogbu and Mani emphasise the need for central coordination of S&T policies and the importance of knowledge-based decision-making. They take a top-down approach where, by increasing the stock of knowledge, the government will be able to make better decisions, based on actual needs and own agenda. As a result they can cater to the needs of their societies as a whole, and not to particular sectoral interests or the agendas of international donors or other institutional agencies. Both authors are essentially concerned with science policy as described in my introduction to chapter two, "governmental efforts to support S&T development while exploiting its results to reach political aims". And although they recognise the need to involve stakeholders in setting the agenda for S&T, they lean more towards the standard view described above, where scientists and engineers play the central part.

Subbiah takes a different position in arguing for a politics for science, described in chapter two as concerning "the interaction between science and power, as the social control over knowledge". His main point is that government cannot set the direction of S&T alone, but policy must be influenced by civil society in order for science and technology policy agendas in developing countries to address the needs of the poor. (Subbiah, 2004) Subbiah calls for a two-way dialogue, in which the communities articulate their needs on the one hand and where government, policy-makers, academicians and industry recognise and respond to these needs on the other hand, in an ongoing back and forth process. He points out that the poor is a large and heterogeneous group and lack the mechanisms of needs articulation and argues for the need of intermediaries, which could be academics, non-governmental organisations, charitable trusts or civil society groups, that are close enough to experience and recognise the variety of needs and at the same time able to articulate them in a way that the government and policy makers can understand and appreciate. For this dialogue to be democratic and the communication effective, the actors must have equal status. Subbiah argues for need to mobilise civil society in order to change the political agenda on science and technology, and he emphasises the important role played by NGOs.

Subbiah emphasised the need for a bottom-up approach where S&T policies first of all should respond to a wider set of interests, and civil society in particular. For S&T to have an impact on the lives of the poor there must be developed mechanisms for needs articulation and this should then be the base for S&T policies and further policy making. By arguing for equality between stakeholders, he leans towards the opposite view of the authors above, by giving no special status to scientists or engineers in setting the agenda for S&T.

The need for policy frameworks and an articulated vision, as argued by Osita Ogbu, and the need for involvement of end-users and NGOs, and ways of promoting cooperation as argued by Arunachalam Subbiah, were among the concerns and reasoning behind the toolbox presented by Wiebe Bijker at the conference[8]. He presented an approach that operates in between the two above, by emphasising policy dialogue between various stakeholders, coordinated centrally by public agencies. He pointed out the central role that science and technology play for developing countries and the need for holistic and contextualised policies that address a wide set of issues and presented a methodology for analysing the research, technology and development (RTD) situation in a country. This RTD "diagnostic" study should enable a policy dialogue, involving stakeholders in building research and development policy. (Bijker, Leonards, Wackers, 2001)

Based on a social constructivist perspective, the methodology argues that as different relevant social groups negotiate - the meaning of one technology can change. Therefore, by involving different groups, there will be different definitions of problems and different possible solutions, as well as interpretations of success and failure. As Science and technology is constructed by a wealth of groups, it is necessary to "address issues in the wider cultural, political and economic milieu when formulating STD policies" (Idem. p. 15).

Bijker argues for the need of a situation analysis, which includes analysing the national policy making processes on RTD as well as the institutions, organisations, regulations and settings that make up the RTD landscape. Formulation of goals and establishment of consensus on priorities and strategies should take place in a policy dialogue that involves a variety of stakeholders, such as public authorities, research communities, private sector and NGOs, and thereby strengthen the relevance and support for the policy. By understanding also the concept of development as a value laden social construct, as science and technology, it becomes important to establish development goals through a policy dialogue that involves a variety of social groups.

[8] Wiebe Bijker is professor of technology and society at the University of Maastricht, the Netherlands

Bijker presented the concept of policy dialogue as an open and ongoing learning process that should lead to a strengthening of the policy making infrastructure and build trust and understanding among its participants. It must be open by not having fixed goals from the outset, but be reflexive and respond to the dialogue, it should be open to a variety of actors and the results should be available to provide for a learning process, valuing successes and failures as part of the process itself. (Idem. p. 22)

The development of S&T policies is a complex process, and the debate at the Providing Demand workshop showed the need to recognise and reconcile the various approaches, from the centralist approach of government initiated and led development, based on a coherent national vision, to the participatory approach of user-orientation and local focus. There is a blurring of boundaries where one can find elements of both positions in the various contributions. S&T policy needs to be based on the recognition of a variety of political, economic and cultural issues, and to cater for the interests of civil society as well as private and public sector. On the one hand there is the need to build S&T infrastructure that can respond to these interests, and on the other hand there is the need for mechanisms to articulate the variety of needs.

A constructivist perspective improves the understanding of the context in which S&T policy operates, and can stimulate a process of politicisation of science by recognising the influence of various social groups. The methodology proposed by Bijker suggests a policy dialogue, responding to the plea from Subbiah for civil society participation, likewise, by emphasising the need to contextualise S&T policy and the recognition of a variety of expertise, the methodology may help to stimulate a process of scientification of politics and respond to the plea from Ogbu for knowledge based development strategies.

When describing the processes of scientification of politics and politicisation of science, presented in chapter two, Weingart were referring to industrialised countries with rich networks of knowledge producing sites. Mouton (2004) argued that it is in this distributed system of knowledge production that demands emerge from different interests. However, in developing countries, without this rich density of institutions, networks or civil society, demand must be created and articulated for different people. The cases of MCRC and IDE above provide examples for the mediating role civil society organisations can play by ensuring mechanisms for needs articulation in knowledge networks that involve a variety of local expertise and knowledge as well as scientific expertise in a Mode 3 type of knowledge production. The same mechanisms for needs articulation must be present and recognised in order for a policy dialogue to be sensitive to the problems and needs of the population in developing countries.

5. Conclusions

The interplay between stakeholders from different policy cultures; academic, bureaucratic, economic and civic, has led to changing paradigms in science and technology policy in the North, from the science push model to demand pull and user orientation. Since the 1970s and 1980s, science policy is increasingly responding to demands from economic and civic interests. These demands emerge from a rich networks of knowledge producing sites, with supply and demand of knowledge flowing back and forth, as scientific knowledge becomes increasingly important for decision making in the knowledge society.

Gibbons et al. (1994) see in these trends the emergence of a new type of knowledge production and a shift from a traditional disciplinary based Mode 1 to a problem-based Mode 2, which is focused on social rather than academic accountability.

The changes of policy paradigms from a science push model to demand-pull had a parallel in development cooperation, where technology transfer was challenged by participatory approaches and demand-led research. The Mode 2 type of knowledge production has been argued as supportive of this shift towards contextualised and demand-oriented development research. However, as Mouton (2004) points out, Mode 2 is based on a Northern paradigm, where demand emerges, with equal chance to be heard and met. This does not apply to the situation in developing countries where there is less density of networks and large inequalities in terms of status, economy and needs. In this situation S&T is more likely to benefit capital strong interests. For S&T to respond to the needs of the poor, their demands must be stimulated and articulated.

5.1. The need for networked Approaches

In my analysis of three cases of pro-poor agricultural research I have found that neither of them can be fully described by the ideal-typical distinction of Mode 1 and Mode 2, but takes a step further and includes elements of both in different ways. One case leans more towards direct user involvement, another is more based on scientific expertise, one takes its starting point at a local level and broadens its scope, and another takes a global perspective and adapts to local needs. They all involve some form of networked expertise, within one organisation, within a lose group of organisation or within a strong partnership of organisation, ensuring on the one hand the scientific expertise and quality and on the other hand the relevance and usefulness to the needs of the end users – small scale farmers.

The work at Murugappa Chettiar Research Centre (MCRC) has several characteristics similar to Mode 1; it represents an academic context in its capacity as a scientific research centre with disciplinary trained scientists and internal scientific criteria to assess the quality of its research. It does not carry out research in transdisciplinary ways as Mode 2, but encourages multidisciplinary approaches. However, as a NGO, its research culture places the needs of rural poor at the core of its activities and technology is developed and evaluated based on its efficiency in improving their situation. Scientists work in heterogeneous and flexible teams that also include non-scientific expertise. Furthermore, it interacts with local communities and organisations in testing and further adaptation of technology.

International Development Enterprises (IDE) carries more of the characteristics of Mode 2; it bases all research in direct response to the articulated needs of stakeholders and involves a variety of actors in finding solutions of the particular problems. However, it involves disciplinary based expertise in developing and evaluating the technology.

The Hybrid Plant project combines disciplinary research and quality assessment with local and political expertise to respond to particular needs in adapting and disseminating the technology, which is subject to a wide range of political, economic and ethical criteria.

In all the three cases, a combination of disciplinary expertise and contextualised knowledge was involved in technology development. By means of establishing networks with a wide variety of actors, different expertise is linked up to attend a broad spectre of interests and considerations while responding to needs of the poor.

Secondly, various expertise and quality criteria are involved as the development process evolves and different actors enter and leave the networks at different times, allowing for flexible approaches responding to the context.

The knowledge production as seen from Murugappa Chettiar Research Centre, International Development Enterprises and in the Hybrid plant project suggest that the ideal-typical concepts of Mode 1 and Mode 2 are too strict to reflect the way knowledge production is organised in these cases. The cases show the need for networked approaches where needs are identified and articulated through the involvement of a variety of stakeholders and expertise, allowing for both disciplinary and local knowledge in contextualised approaches. This supports the plea by Box (2001) for a Mode 3 type of knowledge production, by knowledge networks that cut across Mode 1 and Mode 2.

5.1. The need for articulation of Need

The social construction of technology approach (SCOT) allow for an appraisal of the practical impact that the level of involvement by the rural population had in the three cases, in identifying problems and steering the direction of the technological development.

The direct participation of farmers and localised production of technological solutions is a core element of the IDE approach. This has resulted in simple technological solutions that are recognisable and can be further adapted and maintained by the farmers themselves, such as the treadle pump.

In the MCRC case, scientists saw the opportunity offered by the algal technology and adapted this to the needs of rural women. The technology was unfamiliar for the rural population, but the familiarity of MCRC scientists with their situation and their involvement in further development ensured that the technology was adapted to local contexts and needs.

The hybrid plant project is the furthest removed from farmer involvement and also the technology, which they can influence the least as no adaptation or reproduction of the hybrid plant seeds can be done by the farmers themselves.

In all the three cases, the level of involvement of the poor influenced the choice of technological solutions from the outset, and thereby also their possibility of adapting it further. This emphasise the importance of understanding the social processes that shape science and technology, by recognising the social groups that are involved as well as the power structures that emerge as the meaning of facts and artifacts stabilises. This underlines the need for articulation of the needs of poor, in order for them to profit from developments in S&T.

The cases of IDE and MCRC exemplify the important role played by NGOs in providing mechanisms for needs articulation and mediation of demands that otherwise would be excluded from the emerging power structures. While the IDE approach is based on the articulated need of farmers through participatory methods, MCRC bases its research on closeness to the field, which enables the scientists to interpret technology with the needs of the poor in mind.

The case of the hybrid plant project shows that also the private sector can play a role in pro-poor research and development. Through partnerships between private and public interests, resources otherwise directed solely towards capital-strong actors may benefit wider groups of society.

5.3. The need for policy Dialogue

The 2004 workshop, Providing Demand, presented the diversity of approaches in the contemporary debate on S&T for development, and so also on the issue of whose demands should be involved in setting the S&T agenda. Two general positions can be identified:

1. Centralist, top-down approach, where the bureaucratic policy culture should set the goals and priorities, based on academic interests and demands. Characterised by Mode 1 type of knowledge production.
2. Participatory, bottom-up approach, where demands from civil society should determine the S&T agenda. Characterised by Mode 2 type of knowledge production.

However, the discussions at the workshop showed that the distinction between these positions is blurring. Proponents of a centralist approach recognised the need for wider stakeholder interests to inform government policy, while proponents of the participatory approach recognised the importance of mechanisms for dialogue with government and academia.

The methodology for RTD diagnostic analysis and the toolbox presented by Bijker at the workshop recognises both approaches by arguing for S&T policy making based on policy dialogue. Like the need for contextualised, networked approaches to knowledge production, including disciplinary and local knowledge is recognised in the Mode 3, so does the methodology emphasise the need to understand the social, political and economic context that lay at the base of S&T policy. It offers a practical tool to involve a variety of stakeholders in setting the goals and priorities that shape its direction, by means of a policy dialogue.

The constructivist approach of the methodology behind the toolbox, emphasises the need for involvement of a variety of stakeholders in contextualised policy articulation, recognising S&T as shaped by relevant social actors. This will strengthen the sensitivity towards demands from various groups. However, for such a policy dialogue to reflect the reality of needs in a society there is also the need to recognise the inequalities of power among the stakeholder groups involved. This would mean to take a step further in promoting and ensuring mechanisms for needs articulation by the poor and recognise the important role played by civil society actors.

By recognising various expertise and thus a broader perspective than the process of scientification of politics recognised by Weingart (1997) the process of policy dialogue could stimulate knowledge-based policy-making. Secondly, by allowing for the articulation of various needs, the process could stimulate a politicisation of science more in response in the needs of poor.

5.4. Theoretical implications and suggestions for further Research

There is a need for contextualised policies that address a wide set of issues for science and technology to fulfil its potential of contributing sustainable solution to problems of developing countries. The study of science, technology and society has contributed to increased understanding of the processes that shape S&T and offers a variety of ways to conceptualise these developments. Having the opportunity to attend the Providing Demand workshop I was first taken back by the vide variety, the diversity in approach of the participating authors. There was not one agreed direction forward. Instead, the workshop presented an unfinished map of more or less trodden paths, coming and going in different directions, sometimes crossing, sometimes running parallel; a diversity of epistemological perspectives, target issues and methodological approaches. And as such it might be quite the correct picture and introduction to get to the field of science, technology and development. The developments in the field of science policy and the developments in the field of STD call for greater diversity in approach and at the same time the need for recognition of this diversity in order to benefit from it, by allowing for a variety of contextualised approaches.

Science and technology policy studies have described the trends and changes of direction in S&T and in the way knowledge has been produced, describing the impact of changing demands. Demand has meant the increasing influence of civil and economic interests over the direction of S&T and it is in this paradigm that the Gibbons thesis is based. In the development discourse, however, demand has had a different meaning, of the need to make S&T more demand oriented, to respond to problems of the poor and where demand is not present, but needs to be articulated. My discussion of the Gibbons thesis shows the need to understand the context in which the contextual frameworks we use are developed. Furthermore, the empirical cases studies suggests the need for more flexible and networked approaches to allow for a better understanding, where ideal typical models may disclose rather than reveal important characteristics of the development context.

The constructivist approach to the study of science and technology for developing countries allows for recognition of how social processes shape the direction of S&T policy. However, the case studies suggest also the importance of recognising how the same social processes can exclude groups from influence. The constructivist perspective in STS studies can contribute to an understanding of the need to provide mechanisms for the articulation and inclusion of needs in science policy making.

More empirical studies of different mechanisms for needs articulation are necessary. Particularly of the role and influence of NGOs in policy making; how are the needs of civil society translated in demands towards policy makers, what role does international organisations and networks play in influencing their agendas

Other issues for further research are:

- The role of information and communication technologies in politicising science in developing countries, the process of medialization of the relationship between science and politics, described by Weingart (1997)
- The role of knowledge networks in reinforcing differences in power relations, as a way of excluding rather than including the influence of various demands
- Review of different theories and models that approach the relationship between need and interest and demand and knowledge production
- How do demands compare in countries with rich network of institutions versus countries with fragile systems

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Online resources:

Murugappa group, http://www.murugappa.com

Appendix

Key Informants at the Providing Demand workshop were:

- Dr. Moussa Cisse, Research Coordinator, ENDA Energy, Senegal,
- Mr. Julius Court, Research Fellow, Research and Policy in Development (RAPID) Programme at Overseas Development Institute (ODI), UK,
- Mr. Paul Dufour, Senior Program Specialist, International Development Research Centre (IDRC), Canada,
- Dr. Jacques Gaillard, Director of the Division of Planning and Coordination at the Department of Technical Cooperation, International Atomic Energy Agency, Austria
- Dr. Gerti Hesseling, Chairperson, Netherlands Development Assistance Research Council (RAWOO), the Netherlands
- Professor Johann Mouton, Professor in Sociology and Director of the Centre for Research on Science and Technology, Stellenbosch University, South Africa,
- Dr. Osita Ogbu, Executive secretary of African Technology Policy Studies Network (ATPS)
- Dr. Arunachalam Subbiah, M.S. Swaminathan Research Foundation, India.

Further participants to the Providing Demand workshop were:

- Professor Cynthia Bautista, Professor of Sociology and Dean, College of Social Sciences and Philosophy, University of the Philippines, Philippines
- Professor Wiebe Bijker, University of Maastricht, the Netherlands
- Professor Louk Box, University of Maastricht, the Netherlands
- Mrs. Marie de Lattre-Gasquet, Special Advisor to the Director General of French Agricultural Research Centre for International Development, CIRAD

- Dr. Sunil Mani, United Nations University, Institute for New Technology, the Netherlands
- Dr. John Mugabe, Science and Technology Advisor to the New Partnership for Africa's Development (NEPAD), Executive Secretary of NEPAD's African Ministerial Council on Science and Technology
- Professor Lea Velho, United Nations University, Institute for New Technology, the Netherlands
- Mr. Theo v.d. Sande, Interim Head of the research and communication department, Ministry of Foreign Affairs, DCO/CO
- MS. Caroline Wagner, Research Leader, RAND Europe, the Netherlands