KNOWLEDGE PRODUCTION, AGRICULTURE AND COMMONS: THE CASE OF GENERATION CHALLENGE PROGRAMME

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To Radhika,
for reasons best known to her

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LIST OF ABBREVIATIONS

AAU	Anand Agricultural University
AICRIP	All India Coordinated Rice Improvement Programme
ARC	Austrian Research Centres
ARC/WARDA	Africa Rice Center/ West Africa Rice Development Association
ARIs	Advanced Research Institutes
ARBN	Asian Rice Biotechnology Network
AUTM	Association of University Technology Managers
AYT	Advance Yield Trial
BAU	Birsa Agricultural University
BF	Barwale Foundation
BIOTEC	National Center for Genetic Engineering and Biotechnology
BMGF	Bill & Melinda Gates Foundation
CBPP	Commons Based Peer Production
CGIAR	Consultative Group of International Agricultural Research
CIMMYT	The International Maize and Wheat Improvement Center
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement
COPs	Community of Practices
CPRs	Common Pool Resources
CRRI	Central Rice Research Institute
CRURRS	Central Rainfed Upland Rice Research Station
CSGPs	Complex Scientific Global Problems
CSU	Charles Stuart University
CURE	Consortium for Unfavourable Rice Ecosystem
DBN	Drought Breeding Network
DFID	Department for International Development
DRR	Directorate of Rice Research
DO	Disciplinary Orientation
EAP	Externally Aided Programme
EC	European Commission
EIFPBP	Eastern India Farmers' Participatory Breeding Project
EIRRP	Eastern India Rainfed Rice Project
FDGs	Focussed Group Discussions
FLD	Field Level Demonstration
FOSS	Free and Open Source Software
GCP	Generation Challenge Programme
GPL	General Public License

G*E	Genotype-Environment
IBP	Integrated Breeding Platform
IASC	International Association for Studying of the Commons
ICAR	Indian Council of Agricultural Research
ICT	Information and Communications Technology
IDRC	International Development Research Centre
IFAD	International Fund for Agricultural Development
IGKV	Indira Gandhi Krishi Vishwavidyalaya
IITA	International Institute of Tropical Agriculture
IPR	Intellectual Property Rights
IPGRI	International Plant Genetic Resources Institute
IRBN	International Rice Biotechnology Network
IRRI	International Rice Research Institute
JNKVV	Jawaharlal Nehru Krishi Vishwavidyalaya
LGPL	Lesser General Public License
MAS	Market-Assisted Selection
MPUAT	Maharana Pratap University of Agriculture and Technology
MTA	Material Transfer Agreement
NDUAT	Narendra Dev University of Agriculture and Technology
NARS	National Agricultural Research Systems
NagU	Nagoya University
NBPGR	National Bureau of Plant Genetic Resources
NCE	Networks of Centres of Excellence
NGOs	Non-Governmental Organisations
NPK	New Production of Knowledge
NSC	National Seeds Corporation, Ltd.
NSF	National Science Foundation
OYT	Observation Yield Trial
OUAT	Orissa University of Agriculture & Technology
PLACE	Proprietary Local Authoritarian Commissioned Expert
PGR	Plant Genetic Resources
PNS	Post-Normal Science
PPP	Public Private Partnership
PVS	Participatory Varietal Selection
QTL	Quantitative Trait Locus
RF	Rockefeller Foundation
RRN	Rice Research Network
SAUs	State Agricultural Universities
SD	Sahbhagi Dhan
SDC	Swiss Agency for Development and Cooperation

SIDA	Swedish International Development and Cooperation Agency
S&T	Science & Technology
STRASA	Stress- Tolerant Rice for Africa and South Asia
SUA	Sokoine University of Agriculture
TNAU	Tamil Nadu Agricultural University
TOT	Transfer of Technology
UAS	University of Agricultural Sciences
UoAb	University of Aberdeen
UoAl	University of Alberta
UoMi	University of Missouri
URRC	Upland Rice Research Consortium
URSBN	Upland Rice Shuttle Breeding Network
USAID	United States Agency for International Development
VPKAS	Vivekananda Parvatiya Krishi Anusandhan Sansthan
YAAS	Yunnan Academy of Agricultural Sciences

Chapter 1

General Introduction

1.1 INTRODUCTION

Over the last few decades, the production of knowledge has been in constant transformation (Hessels and van Lente 2008). Indeed, our conceptualisation of knowledge itself has been extended by the scientific development, so that knowledge is just as often these days referred to as 'information', importantly referencing the new scientific frontiers of computing, biotechnology and genetics. Knowledge production nowadays is thus understood to refer not only to things like the activities of experimentation leading to publishing of research papers, but also, for example, to the procedures of development for new software and novel plant varieties. Meanwhile, another development has come in the way this knowledge, or information, is produced. This also concerns the final product, it should be stressed from the outset, since the way in which we develop our knowledge is intimately bound up with what we want to do with it; the why, the how and what of knowledge production are intimately related.

Here, we can speak of two contrasting paradigms. On one hand, the production of knowledge is increasingly being framed within the *instrumental framework*, which is interwoven with commercial and economic interests and aimed at promoting the social utility of knowledge that also promotes specific intellectual property rights (IPR) regimes (Gibbons, Limoges, and Nowotny 1994, Krishna 2014). Alongside this development, on the other hand, there is a pluriformity of initiatives in which knowledge is produced in a more open way, based on cooperation, communication and the sharing of knowledge that is mainly produced in globally organised knowledge networks (Ruivenkamp 2015a). This form of knowledge production is often referred to as an *open-source* or *commons-based* mode of developing knowledge – and insofar as it developed voluntarily and outside of traditional (state and business) institutional structures, it derives from the activities of equals, or peers, resulting in the nomenclature of *commons-based peer production* (CBPP) (Benkler 2006).

These very different, ostensibly oppositional developments in knowledge production are particularly pertinent in the domain of the life sciences (biotechnology, pharmaceuticals, plant breeding genetics etc.). In the domain of contemporary agrarian knowledge production, for example, advancement in the science and technology of plant breeding has led to the use of *multiple research tools* for new crop development (Nottenburg, Pardey, and Wright 2002) – such as specific genes, promoters, markers, functional information, and other *enabling technologies* (Hope 2004); efforts are made to organise knowledge production through *involving various stakeholders* and incorporating *different knowledge systems* into the knowledge production process, so that it becomes more *socially relevant* and is better *tailored to the agro-ecological environment*; and initiatives emerge in which genetic engineering research tools are made *freely available for innovation* for *marginalised farming communities* (Deibel 2014, Kloppenburg 2014, Rai and Boyle 2007). Many new kinds of knowledge production are appearing that are organised in a wide variety of (transnational and trans-institutional) networks with diverse stakeholders based on reconciling advanced upstream research with downstream developments involving end-users through the mediating and sharing of knowledge and information (Vroom 2010).

The production of commons is the second current in this thesis. It is based on an awareness that the production of knowledge takes place in networks, often organised at a global level and composed of various scientific disciplines and even different professional groups. This implies that the foundational basis of the production of knowledge within these networks is the cooperation and communication among the researchers, sharing their knowledge, which is in turn developed through this cooperation and sharing. Moreover, each new knowledge production implies new forms of cooperation and sharing among the research members of the existing (or newly formed) networks. In other words, the commonality – which is at the foundational basis of the development of the knowledge production – is reproduced and re-activated (Ruivenkamp 2015a).

By way of case study, in order to understand the social organisation of knowledge production and the perspective of the CBPP mode (the two basic foundations of this thesis), an empirical analysis is made of the Generation Challenge Programme (GCP) of the Consultative Group of International Agricultural Research (CGIAR), which is focused on drought-tolerant knowledge production. This thesis shows how several of these new trends of knowledge production are manifested in complete and/or partial measure within the GCP. Specifically, features of the GCP production of knowledge include international networking, knowledge sharing, upstream research with a clear orientation towards downstream development, delivery mechanisms and a strong connection with the development issues (Basu, Ruivenkamp, and Jongerden 2011). Together, these illustrate that the GCP combines patterns of both the instrumental research framework and aspects of open source and commons. Summarising, this research focuses on understanding the dynamics of the knowledge production in the GCP drought-tolerant rice research network in order to reflect on the ways in which its knowledge production evolves and the implications of this for agrarian knowledge production and agrarian knowledge producing institutions. This is important for the following three reasons.

First, from an academic point of view, it is often argued that the tendency to instrumental knowledge production is an inevitability, with which future knowledge production will increasingly align. Here, the opposition is with the old model of 'science for science's sake', a non-instrumental approach to scientific endeavour, the 'pure', essentially abstract or 'substantiality' approach (Rinia 2007), in which investigation focuses merely on learning about the world, with research goals set by scientists and leading to a disconnection between the context of research (theory) and the context of application (practice), and thence to the idea of a gap addressed through 'knowledge transfer'(Gibbons, Limoges, and Nowotny 1994, Hessels and van Lente 2008, Nowotny, Scott, and Gibbons 2001).

Going beyond this debate, the present research aims to show that the alternative, emergent models of knowledge production within the overall CBPP approach or paradigm indicate that a new, nuanced conceptualisation of knowledge production needs to be developed, one that takes into considerations issues such as scientific complexity and internationally mediated knowledge production.[1] At the level of discourse, the introduction of this new paradigm challenges both the opposites of non-instrumentalism and instrumentalism and also the exclusive nature of the opposition out of which they are constructed. That is, the identification of instrumental approaches that resulted in a paradigm construction in the literature on knowledge production of a new form (instrumental) in opposition to the old form (non-instrumental) itself implied a conclusion to the development of paradigms that is now denied.

Second, this debate on the dynamics of the knowledge production is important insofar as, in the literature, the debate on specifically commons-based knowledge production is primarily focused on the developments within information and communications technology (ICT). This thesis investigates commons-based knowledge production in agrarian research, contributing thus to fill a gap in the scientific literature. Third, referring to the development of new modes of agrarian knowledge production based on sharing, this thesis also reflects on the implications of these modes of knowledge production for the disconnection of agricultural knowledge production from local contexts and its upstream knowledge development, indicating also research implications for agrarian knowledge producing institutions – specifically, those considered in the case study, but by implication, as generalised to the agrarian domain as a whole (and, indeed, beyond, to the life sciences more broadly, at least).

In this research, I have applied a *critical-constructivist* research methodology to analyse the GCP knowledge production in which the three different practices of knowledge production (non-instrumental and instrumental, CBPP and Commons) come together. The research methodology is *critical* in the sense that it critically investigates theories that refer to a dichotomous way of thinking, dividing knowledge production practices into non-instrumental and instrumental even as new forms emerge (and which thus become analysed and misconceived according to that opposition). And the research methodology

1 Complex scientific problems – drought, the focus here, being one such (see below) – are those that are difficult to address with advanced cutting edge technologies and whose complexity, moreover, is exacerbated by the diverse manifestation of the problem in different parts of the globe; internationally mediated knowledge production here refers especially to knowledge production in international networks that include institutions in the West (typically wealthy and technologically advanced, thus providers) alongside (generally recipient) institutions in developing countries (although, of course, the provider-recipient pattern may not apply or may even be inverted, such in the case of plant materials for genetic sourcing – see Chapter 2).

is *constructive* in the sense that it searches for those contradictory developments within the knowledge production of GCP from which further commons perspectives in the knowledge production of GCP can evolve. Moreover, the analysis is focused on unravelling perspectives on a commoning of agricultural knowledge production and indicating theoretical and practical implications for the international public research area of agrarian knowledge production.

This first chapter consists of a general introduction on the research phenomena (i.e. the knowledge production within the GCP), a presentation of theoretical niches that are applied for analysing the knowledge production of the GCP, and the research methodology that is applied for this research. From a reflection on the theoretical niches, I have formulated the problem statement for this research, dividing it into several research questions, which are empirically investigated and described in separated chapters as presented in the outline of this thesis (below, 1.7).

1.2 GENERATION CHALLENGE PROGRAMME

The GCP is an international knowledge production programme related to drought tolerant plant variety development that was created by the CGIAR[2] as a global crop research consortium. The objectives of the GCP were to develop technologies to support plant breeders in developing countries for developing improved plant varieties for the drought prone harsh environments, using plant genetic diversity through advanced genomic science and comparative biology. On one hand, the GCP was focused on conducting advanced upstream research with the help of genomics, molecular biology and bioinformatics, and on the other hand, it also focused on facilitating the downstream delivery of its research results to the farmers' field. In this work, it was well embedded within international networks supporting agrarian knowledge production carried out by the CGIAR research centers, National Agricultural Research Systems (NARS) institutes, Advanced Research Institutes (ARIs) and other developmental organisations (CIMMYT, IPGRI, and IRRI 2003, GCP 2007, Generation Challenge Programme 2003).

Over its more than a decade existence (2003-2014), the GCP had received funding from the following organisations: public organisations – Austrian Research Centres

2 CGIAR is a global consortium for agricultural research and development that aims to contribute to tackling poverty, hunger and major nutrition imbalances, and environmental degradation. Comprising 15 centres – such as the International Rice Research Institute India (IRRI) and International Institute of Tropical Agriculture (IITA) – the CGIAR consortium works in partnership with the National Agricultural Research Centres (NARS), regional research institutes, civil society organisations, academia, development organisations and the private sector. The general objective of all these CGIAR institutions is to generate and disseminate knowledge, technologies and policies for agricultural development (although there has been an intensive debate on whether these organisations have been successful in bringing about development and whether or not other policy directions and institutional re-arrangements should be implemented). See www.cgiar.org

(ARC), Swedish International Development and Cooperation Agency (SIDA), World Bank/CGIAR, Department for International Development (DFID), UK; European Commission (EC), United States Agency for International Development (USAID), CGIAR Fund Council and the Swiss Agency for Development and Cooperation (SDC); private organisations – Pioneer Hi-Bred International Inc, Syngenta Foundation for Sustainable Agriculture and Kirkhouse Trust; philanthropic organisations – the Rockefeller Foundation and Bill & Melinda Gates Foundation (BMGF) (CIMMYT, IPGRI, and IRRI 2003, GCP 2007, 2009, Wanchana et al. 2008).

During its first phase (2003-2009), it mostly concentrated on creating *a foundation of molecular breeding knowledge* – for example, by identifying quantitative trait locus (QTLs) for drought tolerance – and in its second phase (from 2009-2014), the focus was mostly on using this knowledge *to improve crops for stress tolerance in developing countries*. Initially, GCP's work covered all the CGIAR-mandated 22 crops, but in the second phase, it had focussed on just nine of these (wheat, maize, rice, cassava, beans, cowpeas, chickpeas, groundnuts and sorghum). Nonetheless, GCP has remained consistent in targeting the drought problem, or rather, *developing drought-tolerant crop varieties*, which has direct implications for almost all crops in all regions of the world (Bruskiewich et al. 2006, Delannay, McLaren, and Ribaut 2012, Louwaars et al. 2006, Okono, Monneveux, and Ribaut 2013).

It seems entirely reasonable that GCP should emphasise drought-tolerant crop variety development, given the fact that drought is one of the most devastating forms of abiotic stress that curtail crop productivity – severely, in fact – and since it thus represents a major challenge for global agriculture (Nelson et al. 2007). The problem of drought is further exacerbated due to a range of other factors, notably climate change, water scarcity, erratic rainfall patterns and increasing demands on water (for both agricultural and non-agricultural activities). In the case of rice – which is obviously very important from the food security perspective, particularly in Asia – some 25 million ha of rain-fed (rice-growing) land is drought prone (Liu et al. 2006). Manifestly, this is a problem that demands urgent and utmost attention.

There are various approaches to dealing with drought, of which the development of drought tolerant varieties through plant breeding is one of the easiest.[3] Breeding for drought tolerance while simultaneously increasing productivity, however, is very difficult, particularly because of the low heritability of the trait and the unpredictable nature of drought. Therefore, breeding for drought tolerance has to take into consideration of the following traits in three different spheres: i) maintenance of high water status, ii) maintenance of plant function under low water status, and iii) recovery from low water status. These complexities are further reinforced due to the difficulty of identifying

3 For other approaches of drought, please refer Bernier et al. (2008)

causal relationships between genotype and phenotype because of the high degree of genotype × environment (G × E) interactions (Bernier et al. 2008, Kumar et al. 2008, Leung 2008, Nelson et al. 2007, Salekdeh et al. 2009, Tuberosa and Salvi 2006).

Addressing the above mentioned complexities of drought breeding through conventional breeding methods, which depend largely on visual screening can be problematic, as it may incur bias because of the genotype-by-environment interactions. It is difficult to identify the responsible loci for drought tolerance through phenotypic selection and the process of variety development takes a long time. Therefore, the GCP relies on modern breeding strategies, using biotechnology, molecular genetics and genomics. Advancement in these disciplines has led to the development of DNA-marker technology, or molecular breeding techniques, which – through marker-assisted selection (MAS) – identify genes that are responsible for particular traits. This type of selection is unaffected by the environmental conditions and can expedite the process of breeding considerably (Alpuerto et al. 2009, Collard and Mackill 2008, Dreher et al. 2003, Francia et al. 2005, Xu and Crouch 2008).

The GCP approach to drought – plant development through molecular breeding techniques – can be attributed to the advancement of the science and technology of plant breeding (Nottenburg, Pardey, and Wright 2002). This requires multiple tools, such as specific genes, promoters, markers, functional information and other enabling technologies for crop development. However, these tools are also under the purview of proprietary and IPR controls, which may create impediments at the upstream research level – in this case, particularly because too many people/organisations hold the right to exclude others from using them (Hope 2008). This possible underuse of research tools may be regarded as an instance of what has been termed the *tragedy of the anti-commons* (Heller and Eisenberg 1998). Within the GCP, however, efforts are made to overcome such problems through utilising the ICT revolution.

In an effort to maintain and promote technology (tool) accessibility, GCP has developed an *Integrated Breeding Platform* (IBP) and a *GCP Molecular Marker Toolkit. These* provide access to value-added germplasm, as well as to modern breeding technologies, marker service laboratories, and data management and analysis tools, which are further made available under a *global public goods framework* to support breeders in developing countries. These virtual platforms often use open-source formats, such as enabled by GNU (for software) and the (Lesser) General Public License (GPL, LGPL), with which to share information on molecular markers. Indeed, GCP claims that many logistical and technological bottlenecks in using molecular breeding technologies in the developing world are thus overcome by practices of sharing (Delannay, McLaren, and Ribaut 2012, Okono, Monneveux, and Ribaut 2013, Ribaut, de Vicente, and Delannay 2010, Van Damme, Gómez-Paniagua, and de Vicente 2011, CGIAR Generation Challenge

Programme 2009a, 2011).

In view of the previous discussion, within the GCP, the following issues ostensibly appearing contradictory to each other are emerging: such as solving the enormous and multifaceted drought problem from a *single science and technology trajectory* (the molecular breeding approach), paying little or no attention to other drought mitigation approaches, such as crop intensification, development of irrigation systems, drought escape and avoidance, and nutrient and agronomic management practices (GCP 2007, Generation Challenge Programme 2003, 2006, 2010);[4] creating an international horizontal network among diverse set of actors (both institutional and individual) for generating knowledge and other resources to empower resource poor farmers, and yet the building of this network is administered by bureaucratic institutions such as CGIAR and other NARS (GCP 2007, Generation Challenge Programme 2003, 2006, 2010); and sharing of breeding material, knowledge and research tools are expected to take place through the network that requires cooperation among different actors while the research output will be under property framework (under the global public goods framework) (GCP 2007, Generation Challenge Programme 2003, 2006, 2010). These issues require further exploration in order to understand the type of knowledge production that is emerging within the GCP.

Therefore, in this research, the GCP has been analysed as a juncture of these contradictory developments, the aim being to understand the actual practices of the GCP knowledge production mediated by and mediating these contradictions and to consider ways through which these contradictions may eventually evolved. Since the GCP constitutes a colossal programme, one that involves numerous institutions working on thousands of projects on a range of crops in many locations, it was impossible to study it in its entirety. Therefore, in this thesis, the *drought-tolerant rice research network (RRN) in the Indian context* has been studied as a case study with which to reflect on the knowledge production of the GCP.

This RRN received the following four projects from GCP between 2005 and 2014:

1. Developing and disseminating resilient and productive rice varieties for drought-prone environments in India,

2. Detecting and fine-mapping QTLs with major effects on rice-yield under drought stress for deployment via marker-aided breeding,

3. Connecting performance under drought with genotypes through phenotype associations,

4. Dissemination and community of practice for newly developed drought-

4 For details on different drought mitigation strategies see (Bernier et al. 2008, Mitra 2001)

tolerant QTLs pyramided breeding lines.

Through these projects, GCP states, there have been several outputs, in terms of *publications* (CGIAR Generation Challenge Programme 2009a, 2011, Kumar et al. 2008, Kumar et al. 2012a, Mandal et al. 2010, Verulkar et al. 2010, Bernier et al. 2009, Bernier et al. 2007) and in terms of *drought tolerant variety development* (such as Sahbhagi Dhan, Shusk Samrat, Anna R(4) and ARB (6) (CGIAR Generation Challenge Programme 2009a, 2011). In view of these practical results, analysis of GCP knowledge production is restricted here to a study of the general knowledge production process of this RRN focussing on a single concrete product of this network, the *Sahbhagi Dhan rice variety*, to develop insight into the *production of commons in agrarian knowledge production*.

1.3 THEORETICAL FRAMEWORK

In order to understand the knowledge production of GCP, this thesis refers mainly to three conceptual underpinnings that are emerging in the scientific and public debates on knowledge production. These debates are on non-instrumental and instrumental mode of knowledge production, the possible extension of the CBPP mode into agrarian knowledge production, and the generic political-economic debate on *commons* as frame of reference for the emergence of new social relations in the production of knowledge. These three topics are briefly introduced in the remainder of this section, followed by a clarification of my perspective and how this research aims to contribute to these discussions. These conceptual frameworks are further elaborated in the presentation of the concrete empirical research in the subsequent chapters.

1.3.1 Paradigm on Knowledge Production

There are mainly two paradigms in the literature on knowledge production, the non-instrumental and the instrumental. The non-instrumental paradigm was dominant within academia and science policy institutions until the end of the 1970s. This paradigm comprises a curiosity-driven search for the pursuit of scientific truth; it has been highly positivistic and primarily cognitive. Structured by specific, self-defined and self-sustained scientific disciplines and organised within academic-oriented university and research institutions, this approach to knowledge production is assumed to be autonomous from societal influences and tends to be organised hierarchically in terms of its functioning, directed mostly by the scientists themselves and validated by the scientific community after peer review. Within this approach, it is assumed that there is no interaction among academia, industry and society, as such (Krishna 2014).

For several reasons, which are elaborated in Chapter 2, the situation changed after the

1980s, and the production of science was reorganised. As a result, the instrumental knowledge production paradigm emerged. Contrary to the non-instrumental paradigm, the instrumental paradigm is utility driven and oriented towards application. Aiming to achieve extra-academic goals, such as solving social problems or developing commercial products, this type of approach to knowledge production is characteristically carried out within networks by a wide range of actors (so not just scientists), and evaluated according to a broader set of criteria by people outside as well as inside the related scientific and professional field. In this approach, the autonomy of the university is substantially reduced and academic input is generally provided in a transdisciplinary mode (Gibbons, Limoges, and Nowotny 1994, Rinia 2007, Albert and McGuire 2014, Huff 2000, Shinn 2002, Vogt, Baird, and Robinson 2007).

Within the instrumental knowledge production, science is used as an instrument of policy for achieving either societal goals or commercial interest. Governments started pursuing science policy to seek demonstrable economic return linked to industrial innovation, while corporations wanted to exploit science to make money. As a result, the entrenched curiosity of science is replaced with profitability, the disinterestedness of scientists is replaced with material gain, the openness and public nature of science is replaced with secrecy and exclusivity, and the surprise and serendipity of science is replaced with its achievements (Funtowicz and Ravetz 1993, Gibbons, Limoges, and Nowotny 1994, Nowotny, Scott, and Gibbons 2001, Zalewska-Kurek 2008, Ziman 1994, Ziman 2002).

Instrumental knowledge production has been partially manifested and reflected in the literature of knowledge production through a number of overlapping theories: Finalisation Science, Strategic Research/Strategic Science, Post-normal Science, New Production of Science (NPK), Academic Capitalism, Post-academic Science and Triple Helix (Hessels and van Lente 2008, Knuuttila 2013). In this thesis, these theories are synthesised to find patterns that holistically reflect the essence of instrumental knowledge production (Chapter 2). Then, this instrumental knowledge production is problematized by asking several critical questions alongside reference to existing criticisms.

Looking at the knowledge production of GCP – particularly its focus on conducting knowledge production through international networks, its clear focus on solving the drought problem and its effort to include downstream developments – it can be said that the GCP clearly has the instrumental knowledge production paradigm as operative within its overall framework. However, a further analysis of GCP also shows that – within the GCP – criticisms of its instrumental knowledge production have appeared and new modes of knowledge production are evolving (Chapters 2 and 3).

1.3.2 Commons Based Peer Production (CBPP)

CBPP represent the theorisation of a third mode of production, one that is outside the realm of either market (private) or state (public) production systems. The concept of CBPP was developed by Yochai Benkler by observing the trends of free software production mediated through (ICT). According to Benkler (2002), CBPP is based on cooperation, collaboration and collective action rather than on market pricing, managerial hierarchies and contracts. The system functions in a decentralised manner often constructed in a more-or-less informal and loosely structured way. There is no compulsion to participate in CBPP projects, and people get involved and contribute for a variety of reasons, such as for the pure pleasure of creation, a particular sense of purpose and the satisfaction of psychological needs, or, with social causes as motivation, to build social relations for a common purpose and to create certain sense of belonging. CBPP depends on indirect (non-financial, essentially immaterial) forms of reward rather than direct payment – indeed, Benkler argued that CBPP can encourage and develop certain moral and political values, such as democracy, social justice and autonomy. According to Benkler, the theoretical roots of CBPP can be found in the literature on the organisation of production, in the sociological and anthropological literature of gift-giving and reciprocity, in property rights theory and non-property approaches, such as common property regimes and managed commons (Benkler 2004, 2006, Benkler and Nissenbaum 2006).

There are three structural attributes of CBPP: *modularity*, *granularity*, and *low-cost integration*. Modularity refers to the process of dividing different component parts of the end product while it is in the production process. This means that production can take place at different sites, each independent of the others. Granularity refers to the size of the project modules. In order for a peer-production process to successfully pool a relatively large pool of contributors, the modules should be predominantly fine-grained, or small in size. Finally, a successful peer-production enterprise tends to feature low-cost integration, referring to the mechanism by which the modules are integrated into a whole end product. This integration should include both quality controls over the modules and a mechanism for integrating the contributions into the finished product.[5] It is argued that CBPP is vastly superior to the market-based mode of production in terms of efficiency, productivity and innovation than other mode of production. (Benkler 2004, 2006, Benkler and Nissenbaum 2006).

5 This thesis will not discuss the issue of low cost integration as it has little relevance to the product we are discussing. Although the production process drought-tolerant plant variety considered here has multiple agro-ecological sites, the production process cannot be separated from the actual product itself. Low-cost integration makes more sense in relation to software development, where different parts of the product are eventually integrated into a whole (final) product i.e. a piece of software. In our case, the product development is holistic, so there is no need for integration.

There has been a substantial work on CBPP explaining several peer production phenomena, such as software production, Wikipedia, the production of digital videos, social and digital media production and geographical information systems. These studies often confine themselves to the economic aspects of CBPP, such as efficiency in comparison with the mainstream market-based production system, and refer to aspects like motivation and incentives for participation. Moreover, these CBPP studies refer mostly to ICT, and particularly to what may be loosely termed the 'software arena' (where significant development is easier, and, indeed, exploded). Thus, there has been a certain neglect of non-ICT products, and especially those that are composed of both software and hardware – such as plant varieties (genetically modified seeds, the hardware), in which new scientific information (for drought-resistance, the software) is 'inscribed.'[6]

The GCP, I would argue, does exhibit certain characteristics of a new social organisation of *agrarian knowledge production* that appears to have similarities to the CBPP mode in the software arena (Deibel 2013, Benkler 2006). Primarily, the GCP knowledge production is focussed on the construction of international research networks and communities of practice where diverse sets of actors, both individual and institutional, with various capacities contribute in a multi-layered way towards developmental outcomes (Vroom 2010, CGIAR Generation Challenge Programme 2009a, 2011). Because it focuses on a complex problem, moreover, the input of end-users becomes particularly informative to scientific progress – and insofar as complex problems are expressions of complex systems, like society and climate, agrarian knowledge production in particular may usefully benefit from a CBPP approach. This thesis thus aims at extrapolating a wider analysis of CBPP in studying the knowledge production of the GCP rice research network. In so doing, it will emphasise the *qualitative* over quantitative aspects of CBPP in elaborating on the possible emergence of the CBPP mode in the agrarian knowledge production system. (Chapter 4).

1.3.3 Commons

The knowledge production of GCP is also characterised by the perspectives of commons because the knowledge production takes place through an international network developed by a diverse set of actors (both individual and institutional). Building such networks usually involves cooperation and communication among these set of several actors aiming towards a collective goal. Moreover, through this network sharing (in this case of breeding material), the spread of knowledge and information on biotechnological tools (through open-source software) facilitates the emergence of different types of social interactions and social relations – and this becomes the foundational basis of the new

6 (Kostakis, Fountouklis, and Drechsler 2013), on the Helix_T wind turbine, is an exception here, although this study was still limited to the economic aspects of CBPP (efficiency, effectiveness, lowering production and final costs, etc.).

network mode of knowledge production. Then, since this (GCP) knowledge production through network is located in neither the public nor private realms, it refers to a conceptual terra-nullius between the market and state that is the domain of commons (Caffentzis 2008). To further investigate these characteristics, this thesis relies upon an exploration of the concept of commons as developed over several decades.

Indeed, there is a renewed and increasing interest among scholars to give a central place, a fundamental conceptual role even, to commons, the common, and associated ideas. It is used now to refer to different kinds of social relations that, in political terms, go beyond the old capitalist-socialist division. In this sense, the present work again operates at the level of discourse to deny a traditional dichotomy, introducing instead a third way that stands in contradistinction to the more conventional opposite and, therefore, to the exclusivity of the opposition itself. The consideration here of CBPP in relation to drought-tolerant rice research thus resonates with its basis in commons in relation to paradigms and discourses of the philosophies of both science and politics. Socio-economic concerns are paramount in both of these, for the case of science and knowledge production in ways that may be related to, for example, immaterial gain (non-instrumentalism) or the alleviation of human suffering (instrumentalism), and for the commons in respect of the recent history of this idea.

The contemporary development of the concept of commons originated with consideration of *common pool resources* (CPRs), such as land and forests, water bodies and irrigation schemes. Recently, however, the explosion of information technology and especially its software-hardware interface (c.f. above) has led the conceptualisation of resources to be broadened to include the immaterial (here, theoretical consideration of the commons has gone ahead of the practical focus of CBPP, one might say). Thus, non-subtractable, non-rival and non-depletable resources like knowledge have also come under the purview of commons.

In general terms, *commons* refers to a resource, often a complex resource, which may or may not having a clear-cut boundary demarcation, but which is typically shared by many actors at different levels and subject to social dilemma (Ostrom 1990). The sharing of the resource among a diverse group of people requires their cooperation on a non-competing basis, in collaborative and collective action, with communication, reciprocity, trust and participatory decision-making that is often symbiotic and complements the sustainable use of the resource. There are many studies available in the literature in which this particular aspect of *commons as management and governance mechanism* has been highlighted to show the development of self-governing institutions among groups of individuals to administer CPRs for collective benefits. It was this analysis that was extended through extrapolation to understand the development of knowledge commons, particularly as mediated through ICTs (Araral 2014, Dietz, Ostrom, and

Stern 2003, Ostrom et al. 1999, Agrawal 2014, Anderies and Janssen 2012, Berge and van Laerhoven 2011, Hess and Ostrom 2007a).

Apart from understanding commons thus, as a shared resource, they can also be conceived of as an outcome of social production over a considerable period of time due to human-human and/or human-nature interaction, resulting in products like language, knowledge, plant genetic resources (PGRs) and biodiversity (Hardt and Negri 2009, Hardt 2010). Historically, mankind has always organised valuable resources such as PGRs through collective action, and the default mode of economic organisation may be commons-based (Bollier 2002, Ruivenkamp 2015b).

In order to understand commons as a production process, it is important to understand the particular community that is involved in the production process that will produce a common. Hollenbach (2002) states that commons are realised in the mutual relationship of producing commons and building community. However, commons are not only the outcome of a collective action but also represent a 'shared enterprise' in which people participate freely to developing and sustaining them (Deneulin and Townsend 2007). Although there are many different ways through which commons evolve or come into being, they all have the characteristic of 'sharing' and joint ownership (Hess and Ostrom 2007b). This second current in the debate on commons as a production process is still marginalised in respect to governance and management.

I consider the notion of sharing – or access – to be crucial for a reflection on the production of agrarian knowledge, such as of plant varieties that contains both knowledge commons (information that is accessible to a community, such as a network of scientists) as well as natural resource commons (the plants grown by farmers for centuries and millennia developed for germplasm that is maintained out of IPR regimes). A commons perspective can help us to elucidate the different kinds of social and organisational relationships are nowadays emerging and mediated through the networked mode of knowledge production. In this thesis (Chapter 5), the development as a product of the GCP drought-tolerant RRN of the drought-tolerant rice variety Sahbhagi Dhan – which in Hindi means something that is developed through cooperation – has been unravelled from a commons perspective. In so doing, this thesis aims to conceptualise the concept of commons as a way of understanding production processes, along with indicating its key features beyond those of a governance mechanisms/structure, as is usually the case in contemporary academic work on commons.

1.4 PROBLEM STATEMENT

In this study, the GCP is investigated as a juncture of theoretically and practically divergent approaches of knowledge production, emerging in the development of drought-tolerant rice varieties. As explained, this thesis refers to non-instrumental, instrumental and commons (specifically, CBPP) paradigms of knowledge production (specifically, modes of agricultural knowledge production). The GCP operates within the non-instrumental paradigm insofar as its network construction (still) has a top-down management structuring and profit is not an aim – indeed, it has major funding roots in idealistic philanthropic organisations, which smacks of an 'old-school' approach to science. On the other hand, the instrumental knowledge production paradigm within the GCP is manifested through its commitment to building knowledge production networks and instrumentalizing that knowledge for solving the drought problem employing a (biotechnological plant-breeding) scientific trajectory to that end and including various societal actors in the downstream developments. And differently to both of these, the GCP is characterised as part of an international research network that involves the sharing of knowledge and breeding material and allows autonomy to the scientists to build that network further, which illustrates that the GCP knowledge approach shows similarities with the CBPP mode of knowledge production.

Further, intensive forms of cooperation are present in the GCP research networks in which practices of sharing evolve particularly in relation to biotechnological research tools (through the use of open-source software) at the upstream level and breeding material and knowledge at the downstream level in order to *empower resource-poor farmers* in drought-prone and harsh environments and to stimulate context-specific agricultural practices along with advanced science and technology trajectories, which can be seen as being in tune with a commons perspective. Therefore, the GCP is studied as a juncture of contrasting interests in which practically as well as theoretically divergent approaches of knowledge production are emerging in relation to agrarian knowledge production in general and to the development of drought-tolerant rice varieties in particular. Based on this problem statement, the following overarching research objective of this thesis has been derived.

1.5 RESEARCH OBJECTIVE/GENERAL RESEARCH QUESTIONS

1.5.1 Research Objective

The objective of the research is to contribute to a better understanding of the agrarian knowledge production process of the GCP mediated by and mediating three contradictory developments through which different trajectories of agrarian knowledge production are emerging and in which this thesis particularly interested from the perspective of finding opportunities for a commons-based agrarian knowledge production. In view of this objective, the following research questions guide this thesis and the different research papers reported in Chapters 2 to 5.

1.5.2 General Research Questions

How do different forms of knowledge production emerge within the drought-tolerant rice research of GCP? And which practical and theoretical implications can be discerned from this?

1.5.3 Specific Research Questions

1. Which generic patterns of instrumental knowledge can be discerned from the general theorisation of knowledge production? (Chapter 2).
2. What type of knowledge production has emerged within the GCP drought-tolerant rice research? (Chapter 3).
3. How and to what extent does the GCP drought-tolerant rice research embody the CBPP mode? (Chapter 4).
4. How and to what extent can the drought-tolerant rice variety Sahbhagi Dhan, developed within GCP drought-tolerant rice research, be regarded a common? (Chapter 5).

By exploring these research questions, this thesis aims at understanding the kind of knowledge production emerging within the GCP, to investigate the ways in which the CBPP mode of knowledge production that has emerged in the software arena can be applied in the domain of agrarian knowledge, and to indicate ways in which the development of commons can be perceived within the GCP as a mode of production rather than governance mechanism.

1.6 RESEARCH METHODOLOGY

In this research, I have applied critical-constructivist research methodology as explained below. After that, I explain the rationale behind the research design (qualitative case study) and present the criteria used for selecting the specific case-study of the GCP drought-tolerant rice research. This section continues with a presentation of the techniques used to collect data and concludes with an explanation of how the data was analysed and ethical considerations maintained through the research process. Specific issues related to the different research questions are explained in detail in Chapters 2 to 5.

1.6.1 Critical-Constructivist Approach

Insights from the critical-constructivist approach guided this study. The critical-constructivist approach acknowledges the tension between the existing situations with alternative trajectories that might emerge from within an existing situation (Ruivenkamp, Hisano, and Jongerden 2008, Vroom, Ruivenkamp, and Jongerden 2007). Therefore, the first step within this approach here is to make a critical analysis of the existing knowledge production system and its intertwined nature with unequal social relations. Further, based on such analysis, this approach tries finding *room for manoeuvre* or *social spaces* for alternative trajectories that, in certain ways, are more flexible, plural, equitable and democratic. This is achieved by looking at the contradictions within the knowledge production and searching for social spaces in which reconstruction of the dominant paradigm of knowledge production can be developed.

Hitherto, the critical approach has mainly been used in decoding the dominant perceptions of technology as a value-neutral instrument – thereby indicating its inherently political nature but hardly at all investigating empirical opportunities for a possible reconstruction of technology, its development and employment. This thesis investigates such empirical opportunities for the constructive perspective by studying agrarian knowledge production initiatives through which alternative (CBPP and commons) forms of knowledge production are evolving. More precisely, this thesis critically engages with the existing paradigms of instrumental knowledge production, CBPP and commons, and problematizes their existing underpinnings. Then, an empirical analysis of the drought-tolerant rice research is placed within the problematized framework to elucidate the type of paradigm that is emerging in the case studied. Within the critical-constructive approach, there is always constant rotation between theory and empirical data, where initial theoretical understanding directs empirical data collection, which in turn helps in re-innovating the theory. Thus, a new discourse of knowledge production is initiated.

1.6.2 Qualitative Case Study Method

This research applied a qualitative case-study design to understand the knowledge production process of the GCP. A case-study method involves a detailed examination of an event (or series of related events) that, according to the researcher, in some way reveals certain general theoretical principles (Mitchell 1983). Yin (2009) sees the case study as an empirical 'enquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used'. In this research, the phenomenon under exploration is the knowledge production process of the GCP drought-tolerant rice research, and the organising practices (instrumental, CBPP and commons) of the knowledge production of this research is taken as the explanation of the observed phenomenon; the context (the agrarian knowledge production) cannot be separated clearly from the organising practices of knowledge production, while agrarian knowledge production is a contemporary issue that makes good use of case-study methodology as explained by Yin.

This method was purposefully chosen for this research because of its ability to provide detailed insights on complex social and organisational processes. Moreover, this method is best suited to address explanatory questions that are most often starts with either *how* or *why* – as has been asked in the previous section. The priority of this research was to find explanatory patterns through interpretation rather than to measure numerically. Therefore quantitative research methods are not applied while the focus was on explaining the organising processes of knowledge production. According to Van Velsen (1967), a case may comprise a single individual or institution or a group of individuals/ institutions or a combination of the two. The Indian-context GCP drought-tolerant rice research case was selected based on information availability, access, and the importance of the rice crop in the Indian context, along with certain funding stipulations.[7] Often, case study method is criticised because of the small number of cases that are studied and thus issues with the generalisability of the findings. However, the aim of this research is not to produce generalizable findings, but to look for explanatory patterns and develop an in-depth understanding of the GCP rice research case. That is not to say, however, that this type of analysis cannot have wider relevance. On the contrary, it is anticipated that it may directly contribute both to our understanding of the changing dynamics of knowledge production paradigm and to developing agrarian knowledge production systems (such as GCP itself and NARS programmes).

1.6.3 Data Collection Techniques

This research was initiated with a careful reviewing of the GCP mainly from its official website.[8] This was helpful in understanding the aim, scope, structure, organisation and scientific rationality of the GCP. Further, annual reports, projects briefs, project updates, medium-term plan, brochures and other important documents of GCP were thoroughly studied. This initial analysis was helpful in selecting the Indian-context drought-tolerant rice research case and thus in identifying the various actors (individual and institutional) associated with this case. Specific updates, project reports and research papers produced from this rice research network were also carefully studied. All these documents constituted the secondary data of this research.

Once the (individual and institutional) actors were identified, two fieldworks were organised to collect primary data from different actors between April-July 2012 and October–December, 2012 respectively. All the different institutes participating in this

7 This project was funded by the NWO-WOTRO (the Dutch Science Foundation), whose aim is to conduct research based on North-South collaboration, and it was conceived in an Indian context.

8 At www.generationcp.org

rice research network were visited, where individuals and representatives were engaged. Also, each institute in this network has its own farmers' group to conduct participatory research, and initial interviews with scientists revealed that the farmers are indeed an important part of the network's knowledge production, making their perspective an important component of this research. Unfortunately, time and logistical consideration meant that it was not possible to talk to all the different farmer groups associated with all the different institutes. Therefore, farmers groups associated with a single institute were studied in detail, namely, those at the Central Rainfed Upland Rice Research Station (CRURRS), in Hazaribagh (Jharkhand), northern India.

Participant observation (in the case of the farmer's study), semi-structured and unstructured interviews, and focus group discussions (FDGs) were used to gather information for this research. Multiple sources were employed to ensure the credibility of the research findings through triangulation. Interviewees were informed about the research and their consent was sought beforehand. In all, 45 interviews were conducted with scientists, and 23 scientists were interviewed in-depth. Interviews typically lasted for 3-4 hours. Three farming communities from different districts (Chatra, Hazaribagh and Koderma) were studied. Informal talks were held with a total of around 100 farmers (including women) from which 45 farmers were further interviewed in-depth (only farmers who participated in the CRURRS research activities were observed/interviewed). These numbers were not selected beforehand. Primary data collection continued until the information gain from interviews began not to add very much to that already gathered. Scientists were interviewed in English and farmers in Hindi, so language was not a barrier for the data collection as the researcher is fluent in both.

1.6.4 Data Analysis

Each peer-reviewed research paper constitutes the content of one of the four main chapters (2 to 5) of this thesis, in each of which different theoretical frameworks have been applied to analyse the data as explained (above). Insights from these theoretical frameworks are used as descriptive models to guide data collection and as analytical models to identify patterns within the empirical material. Maintaining the essence of the critical-constructive approach, data collection and analysis were performed concurrently, while in the field. Initial perspectives from the theoretical framework shapes data collection and give direction for further observations and interviews that in-turn affords new insights from the data that helps in rethinking the theoretical lenses. Thus, data collection and data analysis are not at all separate entities in this type of research. Each of the main chapters provides a detailed explanation of the theoretical models used to analyse the empirical data.

1.7 OUTLINE OF THE THESIS

With this chapter having outlined the theoretical framework, the problem statement, research questions and research methodology, Chapter 2 discusses the possibilities for going beyond the dichotomy of non-instrumental and instrumental knowledge production. It starts with a presentation of the transition from the former to the latter and then goes on to indicate how certain patterns are manifested within several theories of instrumental knowledge production. Subsequently this chapter reflects on the criticisms of the paradigm of instrumental knowledge production and provides a new set of criticisms that are developed in the particular context of both complex scientific global problems and international knowledge production platforms that aim at solving such problems. In other words, instrumental knowledge production (overtly) and thus the oppositional (non-)instrumental discourse (implicitly) are problematized. Finally, the empirical case of the GCP is placed in the wider perspective of knowledge production for further exploration.

In Chapter 3 a detailed background of the GCP is provided, which is followed by an elaboration on the scientific complexity of the problem of drought. This chapter also provides the methodological considerations of taking the case of drought-tolerant rice-variety development in the Indian context as a central focus for this thesis. Thereafter, this chapter analyses the drought-tolerant rice research case in the light of the five patterns identified in the previous chapter. With in-depth empirical analysis, this chapter shows that a hybrid knowledge-production paradigm has emerged within the GCP rice research network that has elements of both the non-instrumental and instrumental approaches to knowledge production. Further, this chapter also illustrates the implications for such hybrid knowledge-production discourse for agricultural research and development.

In Chapter 4, the knowledge production process of the GCP (in the same case of drought-tolerant rice research) is analysed from CBPP theoretical perspectives, introducing the idea of a different mode of production system conceptualisation. The concept of CBPP is here extended through analysis of the knowledge production of drought-tolerant rice research to the broader study of agrarian non-ICT-mediated knowledge-production systems. The chapter concludes that the main characteristics of the CBPP mode in the software arena are also manifest in the GCP drought-tolerant rice research case, but taking a rather different shape. This chapter ends with a consideration of the wider relevance of the emergence of the CBPP mode in agrarian knowledge production for agrarian knowledge systems.

Chapter 5 shows how, within the GCP knowledge production system, a commons-based development is evolving. This chapter starts with a presentation of theoretical insights from the literature on commons, particularly paying attention to the debate on commons as production systems rather than a mere governance arrangement. This is followed by a description of the empirical analysis of the development of the GCP RRN drought-tolerant variety Sahbhagi Dhan from the perspectives of commons, indicating several features of commons as production system.

In Chapter 6, the main findings are summarised along with the broader theoretical reflections that have emerged from this study. Finally, suggestions are made and the scope for further research considered.

Chapter 2

Beyond the dichotomy of instrumentality and non-instrumentality of knowledge production: the case of Generation Challenge Programme

ABSTRACT

The discourse on knowledge production has identified a shift from the non-instrumentality to the instrumentality approach, generally been argued to be an inevitable and unilateral transition. In this paper, we question this very assumption by questioning some of the key features of the instrumentality discourse, particularly in relation to an international agrarian knowledge production programme named Generation Challenge Programme (GCP). We first provide an account of the non-instrumentality approach to knowledge production and the gradual shift towards instrumentality. Then different theories of instrumental knowledge production have been analysed to find patterns that holistically indicate the essence of instrumental knowledge production. Finally, by providing a descriptive analysis of GCP, this paper argues that the unilateral transition towards instrumental paradigm is not correct as within GCP several non-instrumental patterns are emerging that can go beyond the dichotomous (instrumental-non-instrumental) understanding of knowledge production discourse.

Keywords: Non-Instrumentality; Instrumentality; Knowledge Production; Science Policy; GCP

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2.1 INTRODUCTION

Over the last few decades, the discourse on knowledge production has been shifting from the *non-instrumentality* to the *instrumentality* approach (Rinia 2007, Hessels and van Lente 2008). The non-instrumentality approach comprises of curiosity-driven search for the pursuit of scientific truth; it has been highly positivistic and primarily cognitive. Structured by specific, self-defined and self-sustained scientific disciplines and organised within academic-oriented university and research institutions, this approach to knowledge production is assumed to be autonomous from societal influences and organized hierarchically in its functioning, directed mostly by the scientists themselves and validated by the scientific community afterwards through peer review (Krishna 2014). Within this approach, it is assumed that there is no interaction between academia, industry or society as such. In distinction to this, the *instrumentality* approach is utility driven, oriented towards application. Aiming to achieve extra-academic goals, such as solving social problems or developing commercial products, this type of approach to knowledge production is carried out within networks by a wide range of actors (so not just scientists), and evaluated according to a broader set of criteria by people outside as well as inside the related scientific and professional field. In this approach, the autonomy of the university is substantially reduced and academic input is generally provided in a transdisciplinary mode (Huutoniemi et al. 2010, Gibbons, Limoges, and Nowotny 1994, Rinia 2007, Albert and McGuire 2014, Huff 2000, Shinn 2002, Vogt, Baird, and Robinson 2007).

Within the knowledge production discourse, the shift from *non-instrumentality* to *instrumentality* is seen as an unilateral transition with the assumption that increasingly all the knowledge production programme will be following instrumental approach (Krishna 2014). It is also argued that this shift has been propelled by a variety of aspects such as the inability of 'normal science' in the Kuhnian sense to deal with a wide range of contemporary complex problems, as well as by the increasing contraction of available government funding for the basic sciences, a high demand for applicable scientific knowledge related to technology development and the massification of higher education (Crompton 2007, Funtowicz and Ravetz 1993, Gibbons, Limoges, and Nowotny 1994, Nowotny, Scott, and Gibbons 2001, Turnhout et al. 2013, Zalewska-Kurek 2008, Ziman 1994, Millar 2013). In the literature of knowledge production, the instrumentality approach has been expressed in partial measure through a number of overlapping theories, such as Finalisation Science, strategic research, post-normal science, Academic Capitalism, post-academic science, new production of knowledge (NPK) and Triple Helix, with NPK receiving the most attention in academia and science policy institutions (Hessels and van Lente 2008, Knuuttila 2013, Bouma and Donald 2010, Gross 2006).

In this paper, we first provide an account of the non-instrumentality approach to knowledge production and the gradual shift towards instrumentality and how instrumentality is reflected within the science policy domain. Then the above mentioned theories of instrumental knowledge production have been analysed to find patterns that holistically indicate the essence of instrumental knowledge production. Next, we review the existing critique of the instrumentality approach, adding several critical questions that are required to take into consideration while discuss the overall discourse of knowledge production. Finally, by providing a descriptive analysis of Generation Challenge Programme (GCP), which is an international agrarian knowledge production programme pertaining to drought tolerant knowledge production, this paper argues that the unilateral transition towards instrumental paradigm is not correct as within GCP several non-instrumental patterns are emerging that can go beyond the dichotomous (instrumental-non-instrumental) understanding of knowledge production discourse.

2.2 TRANSITION FROM NON-INSTRUMENTAL TO INSTRUMENTAL KNOWLEDGE PRODUCTION

Historically, knowledge production was organised as an ideal form of scientific enquiry by disinterested individuals who remained committed to particular ethos of communism, a universalistic orientation, no economically steered interests and scientifically organised scepticism; this ethos directed the doing of science and was embodied in social conventions and practices (Merton 1973, Rodriguez 2007, Vogt, Baird, and Robinson 2007). These specific ethos of doing science have been phrased as the Mertonian understanding of science, which have been considered as presenting the non-instrumental approach to knowledge production due to its autonomous development of science and not being disturbed or instrumentalized by economic interest. Other characteristics of this non-instrumental knowledge approach is that it is strictly discipline-based, governed by academic interest and funded by the state, with the researcher enjoying a high level of autonomy and the knowledge he (or she) produces being validated by peers in scientific community. This strictly discipline-based and science directed mode of knowledge production might imply a disconnection of the context of research from the context of application in society, which might be addressed (or not) through the concept of knowledge transfer, but which might not be a guarantee to resolve the distance between scientific development and societal applications (Estabrooks et al. 2008, Gibbons, Limoges, and Nowotny 1994, Hessels and van Lente 2008, Kropp and Blok 2011, Nowotny, Scott, and Gibbons 2001, Zalewska-Kurek 2008, Rinia 2007).

Apart from the disconnection of the domain of research from the domain of societal application stimulating the change-over to a more instrumental approach (see below), another characteristic that raises doubts about the non-instrumental knowledge approach is its non-proprietary nature. Non-instrumental knowledge production is essentially public and open to exhaustive appraisal, critique and analysis – and those who are involved in it are disinterested – unmotivated by material objectives or corporate goals (Moriarty 2008, Ziman 2003).[9] The basic philosophy behind non-instrumental knowledge production is that science has a number of non-material functions in a society such as promoting rational attitude, encouraging curiosity for scientific exploration of the natural world, and developing a cadre of independent and enlightened experts. Within the non-instrumental knowledge production science is seen as an integrating factor in a pluralistic society, and it is useful for shaping the political discourse, settling legal disputation and consumer protection (Jones 2008, Ziman 2003).[10]

The above described non-instrumental knowledge production mode was dominant within academia and policy institutions until the end of the 1970s. Since the 1980s situation changed and the production of science was reorganized. Important stimulus for this change was the assumption that the non-instrumental knowledge approach was unable to deal with the highly complex wicked problems such as climate change, biodiversity and food security. Especially, it was argued that the complexity associated with these problems could not be adequately addressed by the traditional disciplinary perspectives of non-instrumentality. This led to the emergence of a knowledge production that mobilises resources from different disciplines, creating an interactive and integrated framework between scientists, policymakers and societal actors (e.g. NGOs). This involves a complete reorganization not only of the process of producing knowledge but also of its basic assumptions (e.g. including different epistemologies). This criticism on the limited usefulness of the produced knowledge for resolving societal problems coincided with an increasing expense of conducting scientific research together with a contraction of government grants for science. This all *pushed scientific establishments toward dependence on corporate funding* – which, in turn, required from science a demonstrable practical utility and led also to the higher demand on applicable scientific knowledge, especially through technological developments, stimulating a reorganization of the knowledge production towards a more instrumental orientation. Finally, the massification of higher education led to the development of a society, particularly in the West, that is both well informed and willing to confront scientists with criticism and questions. (Funtowicz and Ravetz 1993, Gibbons, Limoges, and Nowotny 1994, Nowotny, Scott, and Gibbons 2001, Ziman 1994, Costanza 2003, Herrick and Sarewitz 2000, Ziman 2002).

These developments towards a more instrumentalized vision of science related to

9 This is an idealistic characterisation, of course; for example, while corporate goals were not historically very relevant to science in this 'pure' form, it could still be very much directed by personal rivalries, institutional issues and other types of 'impure' (base, material) concern.

10 Again, of course, science did also function in a socio-political framing in which it was shaped by existing power structures, directed towards concerns of class-based financial profit, etc.; there never really was or ever could be a genuinely golden age of innocence.

corporate and societal interests were further consolidated by the Bayh-Dole Act in the USA in 1980. This law allowed universities to own patents for inventions made by their employees. A legislation which was taken up by most American and European universities (with the possible exception in Swedish Universities) which consolidated an instrumental knowledge approach within the universities. A whole network of regulations was installed within universities and research institutions ensuring that the universities gave a fair return to their inventors through royalties or equity. This also led the US Association of University Technology Managers (AUTM) to set up a system of ranking universities based on income generated through patent royalties, stimulating further this instrumental knowledge approach. Even the National Science Foundation (NSF) in the USA started promoting this idea through its reports, while in Canada, the science policy was reorganized in such a way that the academic research was directly linked to the government economic strategy of introducing economic competitiveness and innovation through the Networks of Centres of Excellence (NCE) programme. Along with these reorganizations of knowledge production in public institutions towards a more instrumental knowledge approach there are the larger private R&D budgets of globalising conglomerates, investing more in science than sovereign states, which were already characterized by linking science development directly to their specific economic interests. These combined developments have led to a shift in the organization of knowledge production by consolidating and giving priority to instrumental knowledge production in private and public agencies in which the primary concern has become the commodification of knowledge. In the case of state education, it involves the commercialization of universities through things like patenting and licensing and the founding of spin-off companies (Krishna 2014). In the private sphere, it involves things like political lobbying aimed at subverting the public for private interest. Now, the instrumentality of knowledge production has become a pervasive phenomenon, where '*all kinds of scientific activities and results are predominantly interpreted and assessed on the basis of economic criteria*' (Albert and McGuire 2014, Carroll and Little 2001, Fisher, Atkinson-Grosjean, and House 2001, Knuuttila 2013, Radder 2010, Rodriguez 2007, Slaughter and Rhoades 1996b).

2.3 INSTRUMENTAL KNOWLEDGE PRODUCTION

In the production of instrumental knowledge, science is typically conflated with technology and used as a policy instrument for achieving either societal goals or commercial interest (or a fusion or blurring of the two). Governments started pursuing science policy to seek demonstrable economic returns linked to industrial innovation and corporations wanted to exploit science to make money. Instrumental knowledge production was justified whenever it led to profits for the companies, creating wealth in general for society and has pragmatic, visible successes and enhanced the economic competitiveness of a company and/or nation. With instrumental knowledge production, the (relatively) detached curiosity of the scientists in science is replaced by the directive of material gain; the openness and public nature of science is replaced with secrecy and exclusivity, and the surprise and serendipity of science is replaced by specific economic targets and achievements. In addition, the instrumental knowledge production produces intellectual property rights, serving mainly the utilitarian interest of economic and political elites, who have little interest in science in itself, in knowledge for knowledge's sake, in aiming, for example, to enquire more deeply into the world we inhabit. Instrumental knowledge production becomes ever less autonomous and more entangled with other (non-scientific) agendas. The knowledge it produces is not objective in nature nor universal but rather inherently partisan and local in nature. Being addressed primarily to known problems and needs, it is prosaic rather than imaginative and tested pragmatically by market success or problem resolution (Jones 2008, Rodriguez 2007, Ziman 2002, 2003).

Indeed, the transition towards an instrumental knowledge production may be represented by the contemporary trope of 'information' – there is no knowledge any more, just information. The instrumentality approach has been expressed in the literature of knowledge production through a number of overlapping theories, in which various aspects of the instrumental knowledge approach are emphasized. These aspects are reviewed in the following section, ordered chronologically according to the year in they (the theories) were developed (Hessels and van Lente 2008, Knuuttila 2013), indicating the partial (incomplete) nature of their various clarifications of the instrumental knowledge approach, which creates space for our reflection on bringing these partial clarifications together in all-embracing theoretical understanding about the emergence of the instrumental knowledge production (see 2.4).

2.3.1 Finalisation Science

The first theoretical explanation of the shift towards an instrumental knowledge approach is the Finalisation Science thesis which was developed by the Starnberg-Bielefeld Group in the 1970s. The central argument of this thesis is that particular scientific fields have to be matured first in order to be relevant to and included in scientific agendas. According to this thesis, science does not develop in some uniform and internally or externally consistent pattern, but rather as a whole along with the development of particular fields. Based on two specific case studies in environmental and cancer research, this theory showed a complex dynamics through which a discipline evolves, like a scientific paradigm (Kuhn 1970). This comprises three main phases: explorative, paradigmatic and post-paradigmatic (Böhme et al. 1983, Schäfer 1983).

The *explorative phase* is the developmental phase of a discipline before the emergence of theories that assist in its organisation as a scientific field. In this phase, research is aimed at classification, and experiment is inductive in nature; the focus is on discovery rather than explanation. The emergence of a body of theory occurs in the *paradigmatic phase*, when such development is introduced and elaborated for a definitive end. Thus, the focus of research in the paradigmatic phase is determined by the problems of theory, and as the theory matures there develop fundamental understandings of the discipline's main research objects, which are often hierarchically structured. During the *post-paradigmatic phase*, the theoretical developments of the paradigmatic phase are used to explain more complex systems. Unlike the paradigmatic phase, in which the theoretical developments follow an internal logic directing further research, the post-paradigmatic phase is marked by theoretical developments along the paths indicated by external goals. The finalisation of science occurs in this phase, as scientific theories are linked to external goals (Böhme et al. 1983, Schäfer 1983).

From the point of instrumentality knowledge production, this post-paradigmatic phase is the most interesting, as is then that science-society (and science-economy, science-politics, etc.) interactions take place. Here, finalisation becomes a feedback process through which external goals for science are validated outside of science and become guidelines for the development of the scientific theory itself. In the finalisation process, external actors become involved within the research process; society (especially industry, also government) takes on a guiding role in science. The autonomy of traditional science is thus substantially reduced in the finalisation thesis. The finalisation thesis recognises the importance of the utility of scientific knowledge not only for societal (economic, political, etc.) interest but also in its production (Böhme et al. 1983, Hessels and van Lente 2008, Nahuis and Stemerding 2013, Rip and Voß 2013, Schäfer 1983, Stokes 2007). Summarising, the finalisation theory recognises the importance of the utility of scientific knowledge and the crucial role external actors play in defining the goals of the research process which lead to a reduction of science-for-science approach and opens the perspective for an instrumental knowledge approach.

2.3.2 Strategic Research/Strategic Science

The second theory which has given a partial explanation of the shift towards an instrumental knowledge production is the theory of strategic research or Strategic Science. This theory became revitalized during the 1980s, challenging the notion of '*Science, The Endless Frontier*' (after the title of Vannevar Bush's 1945 Report to the US President). In contrast to the perception of "science as endless frontier", demands were made for strategic or targeted research objectives, combining internal scientific quality with external societal relevance. The term 'strategic research' had already been introduced during the 1970s when reference were made to basically, applied research with a long-term perspective. The focal point was the blurring of fundamental and applied research giving priority to applied science with long term societal objectives. The debate on the theory of strategic research received renewed attention through the policy study by Irvine and Martin (1984). In this study strategic research became defined as basic research carried out in the expectation of contributing to the production of a broad base of knowledge likely to form the background to a solution to recognised current or future practical problems (Irvine and Martin 1984, Rip 2002).

In strategic research, the emergence of an instrumental knowledge approach is related to the blurring of the boundary between basic and applied research. It is expected that science will produce strategic knowledge, which is defined in terms of fundamental insights in domains of *high relevance for the economy or society*. In this way fundamental science or science for science development became completely marginalized. Science was place in the function of economic and societal objectives, in a sense it became strictly applied but in a strategical, context-specific sense. Strategic research is an amalgamation of excellence (advancement of science) with context-specific relevance (application of science). On one hand, strategic research is about pursuing excellence in the cosmopolitan world of science, while on the other hand, it also caters to localised and contextualised human and other needs (Irvine and Martin 1984, Rip 2002).

It is also argued that the apparent difference between the fundamental and the relevant components of research is not a principled contrast; this has more to do with the institutional division of labour than with the nature of scientific research. Therefore, strategic research has a strong role to play in regional innovation systems. Strategic research results are expected to create a reservoir of knowledge from where new understandings and also new technologies can emerge. Within strategic research, the emphasis is more on basic than applied research, therefore, but the issue of relevance is also internalised, so scientists enjoy substantial autonomy in conducting their science (so activities range from the theoretical to the applied according to individual/team interests) (Irvine and Martin 1984, Rip 2002).

Summarising, strategic research or Strategic Science characterises a basic research in which scientists maintain their high level of autonomy, but the outcome of the research is generally expected to solve societal problems. The basic emphasis is on basic research, so this mode does consider science and society as separate entities. Similarly, there is a gap between actual research and its eventual take up in the forms of solutions to societal issues (e.g. innovation to stimulate economic growth). According to Rip (2004), strategic research conflates scientific excellence with societal relevance due to the role of science in innovation and decision making. Rip uses the notion of 'Strategic Science' to describe an upcoming regime, which is itself characterised by a re-contextualisation of science in society (Hessels and van Lente 2008, Hessels, van Lente, and Smits 2009, Irvine and Martin 1984, Rip 2002, 2004, Rip and Voß 2013). Specifically, the issue of solving societal problem through science is related to instrumental knowledge production within the strategic research theory.

2.3.3 Post-normal Science

Due to the perceived inability of science – in the Kuhnian sense, as characterised by a positivist philosophy and objective, universal and context-free knowledge production – to tackle the emerging 'wicked problems' (Rittel and Webber 1973), the theory of post-normal science (PNS) was developed. Instead of producing knowledge that lacks a wider socio-political context, PNS aims at engaging science with real-world situations, where facts are uncertain, values are disputed, stakes are high and decisions are urgent. Problems such as climate change and the depletion of the ozone layer, or global food needs and risks associated with agri-biotechnology are the premium focus of PNS. Where 'normal' science tends to divide large-scale problems into small ones and handle specific issues without questioning the broader paradigm, PNS aims to tackle the inherent complexity and uncertainty of the whole; it does this through involving multiple perspectives and with greater reflexivity. PNS brings interactions from several disciplines and focusses mainly on policy supporting research, which shows its inclination towards an instrumental knowledge approach. However, it does not, for example, advocate university-industry partnerships for product innovation but rather focus on policy or system innovations, brought forward by (instrumentalized) scientific developments (Funtowicz and Ravetz 1993).

A striking feature of PNS is that of the involvement of non-scientific actors as extended peer community, somewhat irrespective of their professional qualifications and personal affiliations. This extended peer community is involved as a stakeholder in science for an open dialogue within the knowledge production process and in evaluating outcomes. In the PNS framework, the involvement of non-scientific stakeholders is not intended to undermine scientific expertise but to improve the quality (range) of scientific considerations as instruments for embedding the policy changes in society. Therefore, scientists are expected to communicate epistemic uncertainties to other stakeholders to facilitate transparent and interactive decision-making processes (Funtowicz and Ravetz 1993).

Thus, PNS is based on 'assumptions of unpredictability, incomplete control, and a plurality of legitimate perspectives' (Funtowicz and Ravetz 1993). It is transdisciplinary, context-sensitive and committed to methodological pluralism and concepts of active stakeholder engagement. PNS advocates for an integrative approach and methodology to integrate multi-perspectives and links epistemology and governance. Initially, in the early stages of its theoretical development, the scientific component of PNS was stressed; then, however, it was acknowledged that the PNS has a strong political aspect. PNS now encourages a deliberative approach aiming to reveal political bias and ensure that this is not excessive. For this reason, and because of its incorporation of non-scientific opinion and expertise, PNS is seen as a democratization of science (Bidwell 2009, Frame and Brown 2008, Funtowicz and Ravetz 1993, Kastenhofer 2010, Petersen et al. 2011, Ravetz 2004, Ravetz 2010, Wesselink and Hoppe 2011). Summarising PNS, the issues such as societal participation in producing and validating science, transdisciplinary and the focus on developing extended network for knowledge production are directly related with the instrumental knowledge production.

2.3.4 New Production of Knowledge (NPK)

The new production of knowledge (NPK) theory was developed by Michael Gibbons et al. (1994) in their seminal publication entitled *The new production of knowledge: the dynamics of science and research in contemporary societies*, in which they identified the emergence of a new research practice and style of knowledge production that they referred to as 'Mode 2' in contrast to the existing discipline-based and university-dominant knowledge form, Mode 1. Further revised by Nowotny, Scott, and Gibbons (2001) in 2001, the concept of Mode 2 has been very influential in science, technology and policy innovation circles. In Mode 2, it was argued, that knowledge is produced in the context of its application, indicating the theoretical attachment to an instrumental knowledge approach. It was also emphasized that the knowledge production refers to a rather holistic framework in which the definition of scientific problems, development of particular methodologies and dissemination of scientific outcomes occur together, concurrently.

A second feature of Mode 2 is that it employs a transdisciplinary approach for knowledge production, which means mobilising a range of theoretical perspectives and practical methodologies not only from several disciplines but also from a variety of sources and without necessarily contributing to the formation of new disciplines. Third, knowledge production in Mode 2 takes place within a number of institutions, including, as well as the traditional universities, a variety of institutes, industrial labs, government agencies, think-tanks, high-tech spin-off companies and consultancies. Thus, Mode 2 involves an organisational diversity resulting in heterogeneous practices. A fourth feature of Mode 2 knowledge production which is particular of interest for the shift towards an instrumental knowledge approach is that Mode 2 knowledge production is characterized by intensive process reflexivity. The interaction between scientific and social perspectives involves a constant, conscious modification of research priorities, with a reverse and interactive communication in which the public speaks back and forth with science. The reflexivity, however, seems to be directed on particular the instrumental value of science. And finally, Mode 2 employs a different form of quality control that involves a wider and heterogeneous set of actors (i.e. other than just the science community). Thus, it is argued that the knowledge produced in Mode 2 is a socially robust knowledge (Childe 2001, Estabrooks et al. 2008, Gibbons 1999, 2000, Gibbons, Limoges, and Nowotny 1994, Hessels and van Lente 2008, Holland 2009, Nowotny, Scott, and Gibbons 2001, 2003, Pohl et al. 2010, Zalewska-Kurek 2008). Specifically, the instrumental knowledge approach can be found in NPK in terms of societal inclusion in producing and validation of science, transdisciplinary and knowledge production through networks.

2.3.5 Academic Capitalism

The theory of Academic Capitalism came into existence as a stark contrast to the Mertonian ethos of doing science (referred to above), which was based on four elements: disinterestedness, universalism, organised scepticism and communism of intellectual property. The basic premise behind the development of Academic Capitalism was based on the information that much of the advanced knowledge is contained within the research universities (particularly in the USA) and that there was a need to integrate this knowledge with the intellectual property process as one of the major factors for production leading to economic growth and innovation. Thus, the idea of entrepreneurial universities came into being, which came to play an important role in economic development (through the commercialisation of research, product spin-offs, etc.) (Slaughter and Leslie 1997).

The academic capitalistic theorists refer to the major efforts to form direct links between industry and universities to maximise the capitalisation of knowledge. This is in tune with the spirit of the Bayh-Dole Act, and most universities nowadays are, indeed, pursuing these policies. Research universities have become an instrument for wealth development, as is well reflected in the research policies of the USA and Canada, which emphasise the commercialisation of academic work through the establishment of new trans-institutional research centres (such as engineering research centres in the US and university-industry research centres in Canada). On-campus business parks are another expression of this trend (Albert and McGuire 2014). Indeed, based on a number of case studies, Slaughter and Leslie (1997) argue that universities are performing a number of market and market-like activities within their university settings. These activities include competition for external funding such as grants, endowments, university-industry partnerships and institutional investment in spin-off companies, while scientists and universities are seek to profit through licensing, patents and royalties.

It is argued that within Academic Capitalism, the power of management increases while the autonomy of professional academics is substantially reduced. However, Academic Capitalism manifests in a variety of forms in different disciplines and organisational settings, so such generalisation needs to be tempered. For example, disciplines that are close to the market and have strong links with commercial product development (such as technological fields) receive more attention than those disciplines (such as liberal arts) that have little to do with commercial profit fetching. Accordingly also, researchers with commercially relevant research receive higher salaries than their counterparts who undertake scholarly work with no (obvious, demonstrable) economic benefits. The rise of Academic Capitalism thus implies serious repercussions on the legitimacy, governance structures and organisational arrangements of science and academic culture (Slaughter and Leslie 1997, 2001, Slaughter and Rhoades 1996b, Slaughter and Rhoades 1996a, 2005, Vaira 2004, Shinn 2002). The theory of Academic Capitalism is related to instrumental knowledge production approach in terms of conducting knowledge production through network, encouraging revenue generation through patenting and royalties and reducing autonomy of scientists in the knowledge production process.

2.3.6 Post-academic Science

Until the end of the 1970s, especially in the West, academic knowledge production was organised within knowledge producing institutions such as universities and completely separated from the industrial mode of knowledge production based on consumption and exploitation of knowledge organised within product development institutions such as company R&D units (Dasgupta and David 1994). Then, however, knowledge production started moving towards a new social and cognitive reconfiguration, dubbed by Ziman (1994) as post-academic science. In post-academic science, the cultural and social context of science as a process of knowledge production is explicit. According to Ziman (1994), there are five general interconnected features of post-academic science.

First, because of the fact that science is increasingly expected to deal with transdisciplinary problems, it requires a collective and collaborative effort where researchers share instruments and co-write articles, so science has become a collective activity. Second, because of the fact that the resources available for basic science have been drastically reduced, there is a continuous effort to share resources and a greater emphasis on accountability and efficiency of science, so the value for money directed towards research has also increased. Third, this has led to a greater emphasis on the utilitarian aspect of knowledge, meaning the application of scientific knowledge to develop products or solutions for particular problems and with even the issue of diffusion of such knowledge being valorised. Fourth, the advent of science and technology policy with its bureaucratised and formalised objective scientific indicators has strengthened the competition for resources, so hybrid institutions for conducting research comprised of university-industry-government inputs are emerging. And finally, science has become industrialised through inter-linkages between academy and industry, so scientific funding is coming through contracted research that is expected to have social, industrial or economic applications (Ziman 2000, Ziman 1994).

Ziman (2000) introduced the acronym 'PLACE' to refer to these new developments: science is *proprietary* (knowledge is not necessarily made public), *local* (focused on local technical problems rather than on general understanding), *authoritarian* (researchers act under managerial authority rather than as individuals), *commissioned* (to achieve practical goals rather than in the pursuit of knowledge) and *expert* (researchers are employed as expert problem-solvers rather than for personal creativity). He further stated that this new set of values is in direct contradiction with the Mertonian norms and pointed out that these new developments of science can affect the relationship between science and society insofar as it can diminish the assumption of science as objective and thus as a trustworthy source of knowledge (Baskaran and Boden 2004, Dalgaard, Hutchings, and Porter 2003, Dasgupta and David 1994, Hagendijk 2004, Sutz 2003, Ziman 2000, Ziman 1994). In summarising, within the Post Academic Science, the following values of instrumental approach are emphasized: transdisciplinary mode of knowledge production, utilitarian aspect of knowledge thus the market orientation of science and organisation of knowledge through network for resource sharing.

2.3.7 Triple Helix

The Triple Helix thesis was developed as a new reconfiguration of university-industry-government relations as we move towards a knowledge society where knowledge itself became a major source for innovation and economic development. Earlier, there were two main configurations: a *statist configuration* (where the government leads the innovation trajectory and academia and industry become subsidiary parts of the government agenda), and then a *laissez-faire configuration* (where industry leads the innovation trajectory and government and universities provide ancillary support). In the Triple Helix thesis, first, the role of the university in innovation as well as in bringing socio-economic development through commercialisation of academic research is acknowledged; thus, the concept of the *entrepreneurial university* emerged, in which universities are expected to generate technology, putting knowledge to use, and follow an interactive model of innovation than the linear model of innovation. Second, there is an increasing co-evolution of university, industry, and government that creates an institutionally overlapping sphere where knowledge production is situated. This basically consists of networks and hybrid organisations between the three at the interface: there are reflexive communications between the university, industry and academia, the linear model of innovation is replaced with a different organisational mechanism that integrates with the market, and basic research is also linked with its utilisation through intermediate processes, such as government initiatives to facilitate university-industry interactions. The Triple Helix model also advocates a transdisciplinary approach, where theoretical and practical aspects of knowledge production converge (Etzkowitz and Leydesdorff 2000).

Summarising, the Triple Helix model of knowledge production is related to instrumental approach as it emphasises the symbiotic relationship between the university, industry and government. It is argued that in this model, university, industry and government converge viscerally and create a hybrid organisation that takes shape according to the three institutions. The linear model of utilisation of scientific knowledge is here replaced by taking the market considerations within the overlapping institutional sphere in the first place, through an overlapping reflexive communications within the university-industry-government triad or complex. Therefore, it is important to study the co-evolution of university-industry-government while studying the knowledge production. This theory is also known as 'entrepreneurial science', and considers transdisciplinarity through synthesizing theoretical and practical issues (Etzkowitz 1998, Etzkowitz and Leydesdorff 1998, 2000, Etzkowitz et al. 2000, Leydesdorff and Meyer 2006, Godin and Gingras 2000).

2.4 EMERGING PATTERNS OF INSTRUMENTAL KNOWLEDGE PRODUCTION

In the light of the above review of overlapping theories of instrumental knowledge production, here, we synthesise those theories into five concrete patterns that reflect the essence of the instrumental knowledge production. The theory of the Finalisation Science, strategic research or science, post-normal science, new production of knowledge, Academic Capitalism, post-academic science and Triple Helix have all manifested some specific characteristics which can be perceived as contributing to an overall shift from non-instrumental towards an instrumental perception of knowledge production. These five patterns are transdisciplinarity, market orientation, networking modalities and institutional space convergence, direct societal engagement and extended peer community validation (Table 1).

There has been a plea for crossing disciplinary borders and developing a transdisciplinary approach to solve complex societal problems. *Transdisciplinarity* refers to the mobilization of a range of theoretical perspectives and practical methodologies to solve problems, but, unlike inter- or multi-disciplinarity, it is not necessarily derived from pre-existing disciplines or formative of new ones (Etzkowitz 1998, Etzkowitz and Leydesdorff 1998, 2000, Etzkowitz et al. 2000, Leydesdorff and Meyer 2006, Godin and Gingras 2000, Gibbons, Limoges, and Nowotny 1994, Nowotny, Scott, and Gibbons 2001). This instrumental vision on applying transdisciplinary research is present in the following theories: NPK, Academic Capitalism, Post Academic Science and Triple Helix. However, Finalisation Science and Strategic Science advocates for disciplinary orientation while Post Normal Science inclined towards an interaction between different disciplines.

Another target was linking science to market. *Market orientation* refers to the consideration of utilitarian aspects of knowledge; this tends to involve and emphasise the increasing, market-like competition for external funding, patenting or subsequent royalty and licensing agreements, university-industry partnerships (with a profit component), institutional investment in spin-off companies and product orientation (with a business value), as well as student tuition fees and related (private) educational institutionalism (Etzkowitz and Leydesdorff 2000, Slaughter and Leslie 1997, Ziman 2000, Krishna 2014). Linking science and knowledge production to the market is strongly advocated within the theories such as Academic Capitalism, Post Academic Science and Triple Helix, while other theories do not advocate for market orientation.

Networking modalities and institutional space convergence involve the organisation of research processes in a number of settings for optimal resource sharing; they can also include multi-stakeholder involvement, often of end users (Etzkowitz and Leydesdorff 2000, Gibbons, Limoges, and Nowotny 1994, Ziman 2000). It also refers to the ongoing shrinkage of the space enjoyed by classical knowledge producing institutions, especially universities; this focuses on the hybrid overlapping institutional sphere that has emerged with the increased interaction and networked structure of collaboration between universities, research institutes, private sector R&D and other organisations (Etzkowitz and Leydesdorff 2000, Gibbons, Limoges, and Nowotny 1994). *Networking modalities and institutional space convergence* is highlighted within the theories such as Post Normal Science, NPK, Academic Capitalism, Post Academic Science and Triple Helix, while Finalisation Science and Strategic Science have not emphasised about this.

In these theories the main (instrumental) focus was on involving directly various stakeholders in the development of science. The direct societal engagement was perceived as a necessary tool to guarantee the societal embedment of science for solving the societal problems. *Direct societal engagement* involves the inclusion (perhaps foregrounding) of societal context; here, knowledge production is more inclined towards a clear definition of the societal contribution at which research aims and may include societal representation (of stakeholders) within the research process (Böhme et al. 1983, Funtowicz and Ravetz 1993, Gibbons, Limoges, and Nowotny 1994, Irvine and Martin 1984, Nowotny, Scott, and Gibbons 2001, Rip 2002, 2004, Schäfer 1983). Post Normal Science, NPK and Finalisation Science strongly advocates for direct societal engagement within the knowledge production process, while Academic Capitalism, Post Academic Science and Triple Helix implicitly acknowledge the societal role for science. Within the Strategic Science, there is no direct role of societal engagement, however, the issue of societal relevance has been internalised within the knowledge production process.

Finally, *extended peer community validation* reflects to the fact that knowledge is no longer validated by the scientific community alone but by society at large along with the scientific community. The emphasis here is on the extension beyond restrictive academic circles and incorporates also notions of non-elitism (Funtowicz and Ravetz 1993, Gibbons, Limoges, and Nowotny 1994, Nowotny, Scott, and Gibbons 2001, Krishna 2014). *Extended peer community validation* is emphasised within the theories such as Post Normal Science, NPK and Post Academic Science, while Finalisation Science and Triple Helix is unclear about this. Strategic Science focuses on scientific community evaluation and Academic Capitalism emphasised on novel mode of quality control.

TABLE 1 SUMMARY OF INSTRUMENTAL KNOWLEDGE PRODUCTION THEORIES

Theory	Year	S-to-S Relations*	DO**	Network	Validation	MO***
Finalisation Science	1983	Society has a guiding role for science	Disciplinary	Unmentioned	Unclear	Unclear
Strategic science/ strategic research	1984	Society has no direct role, issue of relevance internalised	Disciplinary, as focus is on basic research	Unmentioned	Unclear, but inclined towards scientific community evaluation	Loosely indicated
Post-normal Science	*1993*	Society has role through public participation	Inclined towards interactions between disciplines	Yes, focus on development of research community	Extended peer community	No
NPK / Mode 2	*1994*	Society has role	Transdisciplinary	Yes	Extended peer community	No
Academic Capitalism	*1997*	Society at large acknowledged	Unmentioned	Yes	Novel modes of quality control	Yes
Post academic Science	*2000*	Utilitarian aspect of knowledge	Transdisciplinary	Yes	Extended peer community	Yes
Triple Helix	*2000*	Society acknowledged	Transdisciplinary	Yes	Unclear	Yes

* S-to-S: Science Society Relations

** DO: Disciplinary Orientation

*** MO: Market Orientation

2.5 CRITIQUE OF INSTRUMENTAL KNOWLEDGE PRODUCTION

In general, many have criticised the entire paradigm of instrumental knowledge production for a number of reasons. Firstly, it is argued that instrumental science is set diametrically against the traditional core academic principles and corrodes the credibility of science. The argument here is that the strength of science lies in cultivating intellectual creativity for discovery and not in its ability for developing commercial products. The obsession for wealth creation through science eventually ends up in locking science in the hands of a few corporations that create conditions for its underuse, thus leading to the 'tragedy of anti-commons', with science failing to address broader social issues, such as poverty reduction, health and environmental problems, and the intellectual development of people (Jones 2008, Moriarty 2008).

Questions have also been raised regarding the ability of market-driven instrumental science to deliver economic development, innovation or wealth creation (and certainly innovation and wealth creation that lead to a more equitable and better society). It is also argued that instrumental science tends to produce scientists who are subservient to state bureaucracies and/or commercial corporations instead of enlightened academic researchers. Moreover, the instrumentality approach has also been criticized, in particular for its ethno-centricity and failure to sufficiently use empirical evidence (Crompton 2007, Moriarty 2008, Nowotny, Scott, and Gibbons 2003, Ziman 2003). Finally, the focus in instrumental knowledge production is placed on the organisation of research instead of the content of science. This has led to the top-down management of science in which many scientists do not perform based on their intellectual instincts (Jones 2008, Knuuttila 2013, Moriarty 2008, Rodriguez 2007, Ziman 2002, Heller and Eisenberg 1998).

Along with these existing criticisms of instrumental knowledge production, here, we ask the following questions on each patterns of instrumental knowledge production that are derived in the previous section. First, given the fact that most knowledge production in developing countries is still organised around non-instrumentality (Datta and Saad 2011), then how that non-instrumentality intercedes with the instrumentality approach of the developed world becomes a (meta-)theoretical issue of immense importance, particularly where knowledge production is taking place within an international network for development, given that there is a long history of 'technology transfer' from the developed to the developing world, and in view of the model or blueprint mechanisms that the developing world is supposed to follow for this. Second, does the very nature of such complex scientific problems force knowledge production to be organised in a more flexible bottom-up manner instead of a top-down managed instrumental knowledge production? Does the sharing of knowledge then become more important in order to tackle such problems – instead of, for example, hiding it through IPR – to confront the tragedy of anti-commons debate?

Third, within the international knowledge production, how do we identify science-society relations? And, further, given the fact that most complex scientific problems require solutions that involve cutting-edge advanced science, how can society in general contribute to that? Fourth, then, at a more purely theoretical level, when disciplinary cutting-edge science has strong role to play in the possible solution of the problem, how do we conceptualise transdisciplinarity? And politically, how do we reconcile international public institutes being involved in knowledge production for knowledge production under the canopy of international public goods with the increasing market orientation of instrumental knowledge production?

In order to explore these concerns rather criticisms of instrumental knowledge production and to find out if the instrumental paradigm has replaced the non-instrumental paradigm (with the assumption that instrumentality would be present in all types of knowledge production programme), an initial descriptive analysis is made on the GCP that is an international agrarian knowledge production programme related to drought tolerant knowledge production. GCP was chosen because of the following reasons: first, its knowledge production is organised in an international network consists of international institutes, national institutes, NGOs, government institutions, think-tanks and farmers organisations as an important factor to study social organisation of research network; second, its focus on reconciling technology oriented upstream research with the downstream development as a working example of instrumental knowledge production interceding with opportunities for bottom-up innovation; third, as GCP's research approach is embedded within the wider discipline of plant breeding, to reflect on the transdisciplinary orientation of instrumental knowledge production; fourth, GCP operates within the larger framework of international public good as GCP and CGIAR are international public institutions, therefore, to reflect on the market orientation of GCP knowledge production; and finally, GCP also aims at including farmers representation within the knowledge production process, therefore to reflect on the role of societal validation and inclusion of society as end-users as postulated by the instrumental knowledge production (Basu, Ruivenkamp, and Jongerden 2011, CIMMYT, IPGRI, and IRRI 2003, Vroom 2010).

2.6 GENERATION CHALLENGE PROGRAMME (GCP)

The Generation Challenge Programme (GCP) is one of the five challenge programmes of the Consultative Group of International Agricultural Research (CGIAR). It was created by CGIAR in 2003 as a time-bound 10 year programme and its aim is to add value to crop breeding, targeting farmers in drought prone and harsh environments. GCP's mission is to use plant genetic diversity, advanced genomic science and comparative biology to develop tools and technologies that will support plant breeders in the developing world in their efforts to produce better crop varieties for resource poor farmers in drought-prone environments. The GCP is a research and capacity building network that uses plant genetic diversity, advanced genomic science and comparative biology to develop tools and technologies that help plant breeders in the developing world produce better crop varieties for resource-poor farmers. GCP's activities are organised into five overlapping and interactive sub-programmes: the genetic diversity of global genetic resources; comparative genomics for gene discovery; trait capture for crop improvement; bioinformatics and crop information systems; capacity-building and enabling delivery (CIMMYT, IPGRI, and IRRI 2003, GCP 2007, Vroom 2010).

As it appears from the website, GCP is unique within CGIAR and the larger agricultural research –for-development community. It was founded to unlock the potential of plant genetic diversity as a means to modernise crop improvement programmes so that these serve the resource poor. GCP relies on a network that can enable it to exploit significant resources –funds, skills, equipment, knowledge and social capital-through partnerships with public and private institutions and initiatives. A critical benefit of the network as claimed by GCP is that it provides access to vast stores of plant genetic resources as well as to the cutting-edge technologies and scientific expertise needed to make these resources more useful for crop improvement. GCP's network structure is a useful model for overcoming some of the traditional barriers that tend to frustrate innovation in established R&D systems, such as broken links between basic and applied research, and weak partnerships between advanced research institutions and national programmes in developing countries (CIMMYT, IPGRI, and IRRI 2003, GCP 2007, Vroom 2010).

GCP research products are delivered to other researchers (including gene bank curators, plant physiologists, geneticists, breeders and others) to enhance the efficiency of plant breeding programmes in developing crop varieties with traits that match the needs of resource-poor farmers in marginal environments. More precisely within GCP there are several platforms like Genotyping Support Services (GSS), Molecular Breeding Platform (MBP) and Genetic Resources support Services (GRSS) which create a set of plant breeding support services as sustainable public goods. *These* provide access to value-added germplasm, as well as to modern breeding technologies, marker service laboratories, and data management and analysis tools, which are further made available under a *global public goods framework* to support breeders in developing countries. (Delannay, McLaren, and Ribaut 2012, Okono, Monneveux, and Ribaut 2013, Ribaut, de Vicente, and Delannay 2010, Van Damme, Gómez-Paniagua, and de Vicente 2011, CGIAR Generation Challenge Programme 2009a, 2011).

Summarising, GCP's approach to knowledge production in drought research employs a three-fold strategy: first, there is the application of molecular breeding technologies/ instruments in upstream research to achieve precision in breeding; second, it aims to make its technological breakthroughs available through practices of sharing, such as ICT under the GNU and (L)GPL framework; and third, it looks to link the upstream research with downstream development, mediating through the development of a multi-stakeholder network among advance research institutes, CG centers, NARS, NGOs and farmer's organisations to make an impact at the farmer's field (CIMMYT, IPGRI, and IRRI 2003, CGIAR Generation Challenge Programme 2009a, 2011).

2.7 REFLECTION ON GCP FROM DIFFERENT KNOWLEDGE PRODUCTION PARADIGM

Concerning the theoretical assumption of an interrelation between transdisciplinarity and instrumental knowledge production, the analysis of the GCP reveals that its research approach is, in fact, strongly embedded within a disciplinary framework. The GCP tries to solve the problem of drought mainly through a broad plant-breeding trajectory. Therefore, GCP's effort to solve a particular societal problem (namely drought) is related to an instrumental paradigm and its disciplinary framework (i.e. the plant breeding trajectory) is inclined towards a non-instrumental paradigm. Moreover, as GCP neither encourages a market orientation theoretically as assumed in the instrumental paradigm of knowledge production and nor does it seek or in any way foster a commodification and commercialisation of research results through the IPR regime. On the contrary, at the upstream level, the GCP aims at sharing research tools (such as molecular markers) through open source licensing (GNU, GPL and LGPL) to create global public goods for agricultural research and development, while at the downstream level, GCP products of are not patented but often registered within the public research institutions. Therefore, in regard to market orientation, GCP is more inclined towards a non-instrumental discourse.

Concerning the network modalities and the institutional space convergence, the research showed that GCP's knowledge production is organised in an international network that includes CG-centers, National Agricultural Research System (NARS) institutes, universities and NGOs. The organisation of knowledge production through this network to some extent represents the instrumental knowledge production paradigm. And finally, GCP's effort to make an impact at the farmer level through mediating downstream delivery can be seen as an example of instrumental pattern of organising direct societal engagement through the inclusion of end-users in the knowledge production process and the validation of science by them in or as an extended peer community.

2.8 CONCLUSIONS

In this paper, we first elaborated the shift from the non-instrumental to instrumental knowledge production and its repercussions within the science policy establishments. This shift has occurred because of the perceived inability of the non-instrumental paradigm to tackle complex societal problems, increasing contraction of state funding for science, massification of higher education and the emergence of proprietary regimes within academia. Within the general discourse of knowledge production, the shift from non-instrumentality to instrumentality is seen as a unilateral transition, with the assumption that the features of instrumentality are or will be present in all kinds of knowledge production programmes. Here, an analysis of various theories of instrumental knowledge production (Finalisation Science, Strategic Research/Strategic Science, Post-Normal Science, New Production of Knowledge [NPK], Academic Capitalism, Post-Academic Science and Triple Helix) reveals that the following five specific patterns can be discerned as emblematic of instrumental knowledge production: transdisciplinarity, market orientation, networking modalities and institutional space convergence, direct societal engagement and extended peer-community validation.

An initial analysis on the GCP knowledge production process, however, indicated problems with the application of this, both in terms of theory (the expression of instrumentalism) and metatheory (the knowledge production discourse of shift and opposition). Neither does the dichotomy between instrumental and non-instrumental knowledge production appear to offer an appropriate characterisation of the knowledge production process of the GCP, and, linked to this, nor does the assumption that instrumental knowledge production has in any way fully substituted the non-instrumental seem justified. Rather, the GCP knowledge production process evidences both instrumental and non-instrumental paradigms and, moreover, as in a certain sense fused. Therefore, a profound empirical analysis on the dynamics of GCP is necessary to find out the kind of knowledge production paradigm that is emerging in GCP case. That is, since the standard discourse appears unsatisfactory as a way of characterising exactly what type of knowledge production is emerging within GCP and quite how different instrumental knowledge production patterns are taking different shape, further, discourse-level investigation becomes necessary.

Chapter 3

Emerging Hybridity in Agrarian Knowledge Production Systems: the Case of Generation Challenge Programme

ABSTRACT

The Generation Challenge Programme (GCP) is an international platform for agrarian knowledge production for a complex scientific problem, namely, drought. The GCP ushered in a new form of knowledge production that reconciles both the upstream laboratorial research and its downstream delivery at the farmer's field. Using the literature on knowledge production, this paper explores empirically the case of GCP drought-tolerance rice research in the Indian context to elucidate the knowledge production process of GCP to sketch a theoretical position on the knowledge production paradigm. This paper argues that a hybrid knowledge production paradigm has emerged within the GCP rice research network that has elements of both the substantial and instrumental approaches of knowledge production. Further, this paper also illustrates the implications for such hybrid knowledge production paradigm for agricultural research and development.

Keywords: Knowledge Production; Networks; GCP; Drought; Rice; India

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3.1 INTRODUCTION

The Generation Challenge Programme (GCP) is an international platform for agrarian knowledge production developed in 2003 by the Consultative Group on International Agricultural Research (CGIAR). The aim of GCP is to create international research networks among CGIAR research centers, National Agricultural Research Systems (NARS) institutes, Advanced Research Institutes (ARIs) and other developmental organisations, and through these networks to address the problem of drought, which is not only a major challenge in global agriculture but also a complex one. Drought is difficult to manage using advanced and cutting-edge science and technologies, and that difficulty is further exacerbated by its diverse manifestations in different global locations (Bernier et al. 2008, Mitra 2001). GCP's approach is based on reconciling upstream research at an advanced laboratory with the downstream delivery of that research product at the farmer's field, mostly through NARS (GCP 2007, Vroom 2010).

In this paper, we study the knowledge production process of GCP that is mediated through research networks. Drought related knowledge production includes research papers, reports, protocol development, agronomic packages, and drought tolerant plant varieties. In addition to being a matter of intrinsic interest, understanding the knowledge production process of GCP is important as it may yield insights into agricultural research and development institutions (such as CGIAR, NARS etc.) of practical value, particularly in respect of complex scientific problems such as drought. Using the literature on knowledge production that is broadly divided in two paradigms, referred to as the non-instrumental approach and instrumentality approach (Rinia 2007), this paper explores empirically the case of GCP drought-tolerance rice research in the Indian context to elucidate the knowledge production process of GCP. This paper argues that a hybrid knowledge production paradigm has emerged within the GCP rice research network that has elements of both the non-instrumental and instrumental paradigms of knowledge production. Further, this paper also illustrates the implications for such hybrid knowledge production paradigm for agricultural research and development.

The paper is organised as follows. Following this short introduction, we outline our theoretical framework for the organisation of elements of knowledge production paradigm. Then, a scientific explanation is provided on why drought constitutes a complex scientific problem and its relevance as a major form of abiotic stress in rice. Next, we describe the research methodology employed for this research, including the criteria that we have used to select the case of drought-tolerant rice research within the GCP. After that, the empirical findings are presented, organised around the organising elements of knowledge production. This is followed by a discursive concluding section.

3.2 THEORETICAL FRAMEWORK

Two main conceptualisations are used in to understand knowledge production: the non-instrumentality approach and the instrumentality approach (Rinia 2007). The discourse on knowledge production has long been dominated by the former. This approach is strictly discipline-based, governed by academic interests and funded by the state. Validation of the empirical information and the methodologies by which it is performed and of the paradigmatic approaches productive of these is performed by peers within the various divisions of the scientific community, within which (parameters) researchers tend to enjoy a relatively high level of autonomy. Steered primarily by scientific interests, this led to a disconnection between the context of research (theory) and the context of application (practice) – a gap that is addressed by investigating the experience of knowledge transfer (Gibbons, Limoges, and Nowotny 1994, Hessels and van Lente 2008, Kropp and Blok 2011, Nowotny, Scott, and Gibbons 2001, Zalewska-Kurek 2008, Rinia 2007). Over the last few decades, this approach has been criticised, leading to the development of the instrumental paradigm.

Built upon a critique of the classical form of knowledge production operative in science generally, the instrumentality approach to knowledge production is determined above all by socio-economic relevance and utility. For instance, criticism has been expressed regarding the non-instrumentality approach's failure to deal with the urgent and complex problems facing the world today – such as climate change, biodiversity loss and food security – due to its focus on the gradual accumulation of knowledge for its own sake (science as an end in itself). It is argued that the utility perspective required for scientific developments to tackle complex problems demands the mobilisation of a range of theoretical perspectives and practical methodologies that can no longer be accommodated within the existing disciplines: since the problems go beyond these confines, they cannot be formulated in such terms. This implies the development of a transdisciplinary approach, rather than the single disciplinary of non-instrumental knowledge production paradigm (Funtowicz and Ravetz 1993, Gibbons, Limoges, and Nowotny 1994, Turnhout et al. 2013).

The instrumental paradigm of knowledge production was significantly enabled by the post-WWII extension, or democratisation of higher education, making this available to the middle and even lower class mass of the population rather than traditionally restricted elite, and thereby implying a broadening of the social concern and associated capacity of science. But this also implies the inclusion, perhaps foregrounding, of societal context. Knowledge production within the instrumentality approach is inclined to a clear definition of the societal contribution at which research aims, as opposed to the non-instrumental approach. This includes the societal representation of stakeholders within the research process (Gibbons, Limoges, and Nowotny 1994, Ziman 1994, Gibbons 2000, Kurek, Geurts, and Roosendaal 2007).

Also emphasised has been a change in the character of knowledge production due to the omnipresence of business: instrumental knowledge production tends to be for capital rather than for people, one might say, developed in recent decades by the thrust of neo-liberalism in relation to governmental funding and the institutionalisation of the market in higher education facilities. Institutional arrangements, research activities and knowledge communication – a major part, in fact, of the whole edifice of 'science' – are both directly and indirectly driven and directed by the focus on making profit form scientific developments (through IPR, licensing agreements, company sponsorship, etc.). Therefore, the institutional space and autonomy for knowledge production enjoyed by classical knowledge producing institutions, such as universities and research institutes, within the non-instrumental knowledge production paradigm are considerably reduced in the instrumental paradigm because the knowledge production space has been shifted from single institution to overlapping institutional sphere, usually organised in a collaborative network among universities, research institutes, private R&D and other organisations (Gibbons, Limoges, and Nowotny 1994, Ziman 2000, Etzkowitz and Leydesdorff 2000).

Indeed, knowledge is no longer primarily related to or even primarily appraised for its contribution to an abstract notion of objective 'truth' focussing on the question 'Is it correct?' Rather, it is concerned with utility, posing the question 'Will it work?' A different kind of science has emerged, oriented towards application and the achievement of extra-academic goals. These may be simply divided into two main categories: solving social problems and developing commercial products (acknowledging that these are not mutually exclusive). In fact, the extent of overlap between the two that one perceives tends to determine and be determined by one's politics. Against those who emphasise the successes and future potential of business to develop the products that solve social problems, others see it as already a primary cause of imminent global and potentially catastrophic crises. The latter position leads toward a rejection of an economics and thus utilitarian science significantly based on private ownership and the development instead of an alternative system, not only emphasising public (state) control, but now also, and increasingly done 'bottom-up', stressing openness and accessibility, or the common wealth (Gibbons, Limoges, and Nowotny 1994, Rinia 2007).

Therefore, knowledge is no longer validated by the scientific community alone as in the non-instrumental paradigm, but by interested parties – which may be localised, constituted by the public as a whole, and generally (but not necessarily) includes the scientific community. Clearly, this production of knowledge beyond restrictive academic circles incorporates non-elitist notions. Related to this phenomenon of extended peer community validation through which utilitarian results are prioritised, knowledge production becomes increasingly embedded in a market orientation. This implies things like an increasing competition among research networks for external funding, the need for the research network to protect and patent its knowledge development and to search for royalty and licensing agreements, the development of university-industry partnerships and the establishment of scientific business parks to facilitate the science transfer and setting up of spin-off companies orientated to product applications (Funtowicz and Ravetz 1993, Gibbons, Limoges, and Nowotny 1994).

Summarising the above discussion on the non-instrumentality and instrumentality paradigms on knowledge production, we find the following to be the main areas of distinction between the two approaches: first, spatial and place based dimensions of knowledge production (such as whether knowledge production is organised within a single institution or within a network); second, disciplinary orientation (whether it is embedded in a single disciplinary boundary or a transdisciplinary framework); third, input (whether end-users and society generally are involved as opposed to simple domination by scientists and scientific interest); fourth, validation (whether knowledge production and is outcomes are validated by scientists alone or by an extended peer community); and finally, orientation (to knowledge for its own sake, or towards utility, including commodification – the utilitarian and/or market orientation aspect). Below, we organise our findings around these five aspects of knowledge production to reflect on the mode of knowledge production that has emerged in the case of the GCP rice research network. First, since the central theme of the GCP rice research network is that of drought tolerance knowledge production, we provide a scientific explanation of why drought is considered a scientific complex problem.

3.3 DROUGHT AS A COMPLEX SCIENTIFIC GLOBAL PROBLEM

Scientifically, drought is perceived as a meteorological and socio-economic phenomenon in which a paucity of water availability can diminish yield. It can occur regularly, such as every year, and irregularly, at any time during the growing season. Categorised for rice basically according to the growing season – as either early, intermittent or late – drought is the most important abiotic constraint of this staple food grain. Globally, some 80 million farmers are working 60 Mha of rainfed rice ecosystem, and drought alone accounts for an annual reduction in rice production of around 18-Mt. In Asia, 23 Mha of rice fields (10 Mha upland, 13 Mha lowland) – roughly 20% of the world's total rice-growing area – is drought prone. In India, drought is a major concern for the eastern part of the country, where almost 10 Mha of the rice-growing area is drought prone, upland and lowland, and which costs losses of some 36% of the average value of total rice production (Bernier et al. 2008, Fischer et al. 2012, Gowda et al. 2011, Kumar et al. 2008, Mitra 2001).

An important science & technology (S&T) trajectory to resolve the drought problem has been the installation of irrigation systems, which is often costly (Bernier et al. 2008, Kumar et al. 2008). Even in irrigated ecosystems, however, drought has remained a problem, recently exacerbated by erratic rainfall patterns and a general water scarcity, thought to be related to global warming. The development of drought-tolerant varieties through plant breeding is regarded as another important S&T solution trajectory, but breeding for drought resistance is very complex. It involves a trait whose expression is controlled by the action and interaction of various morphological, physiological and biochemical characters of different genes and their interaction with those genes regulating the yield potential (a complexity that becomes yet further complicated by the often unpredictable timing and severity of drought). Still, breeders express their confidence in the potential of breeding to resolve the drought problem by emphasising the substantive scientific progress that has been made in the following areas: understanding the physiological mechanisms that impart drought tolerance in rice (Fukai and Cooper 1995); developing new molecular tools; applying these new tools (practical knowledge) for the screening, selection and improvement of rice germplasm for drought (Atlin 2003, Bernier et al. 2007, Jongdee et al. 2006, Lafitte et al. 2006, Venuprasad, Lafitte, and Atlin 2007); developing a closer interaction in the work of physiologists, geneticists and breeders aimed at a more reliable control of water-stress severity and duration at the critical yield-determining growth stages; involving farmers' participatory selection groups as final evaluators (Witcombe et al. 2002) to deal with local variations in soils and landscape for the tailored development of drought tolerant varieties.

In view of these scientific developments, it is also argued that involving end-users – in this case, farmers – may facilitate the dissemination of the new drought-resistant varieties (Bernier et al. 2008, Fischer et al. 2012, Gowda et al. 2011, Kumar et al. 2008, Mitra 2001) and increase the societal impact of these varieties. Before looking at how this occurs within the GCP, we give a short overview of the GCP and the research project and site on which we have focussed, and detail the methods used for our empirical analysis.

3.4 RESEARCH METHODOLOGY

3.4.1 Criteria for Case Selection

Since GCP is a colossal programme – initially focusing on 22 mandated crops (although now being limited to nine) and involving more than 1000 research projects and around 200 research institutions around the globe – for the purposes of this research it was decided to limit the empirical analysis to one specific crop (rice), one specific region (India), and one specific problem (drought) (Table 2). On basis of these selection criteria, we explored the GCP's drought tolerant rice research projects with Indian institutions (mostly NARS) along with IRRI to understand how the organising elements of knowledge production manifest itself in the GCP and what implications can be discerned for agricultural research and development.

TABLE 2 CASE SELECTION CRITERIA

Category	Selection	Rationale
Geographical location	India	• NWO-WOTRO project focus on India • Accessibility of local research institutes • Availability of research data • Quantity/quality of concrete GCP development
Specific crop	Rice	• Rice widely consumed in India • Maintaining rice production is a challenge • Ensures food security
Concern	Drought	• A major problem in rice cultivation in India • 13 out of total 44 Mha rice growing area • drought affected • As an abiotic stress, difficult to tackle • Complexity in conducting research

3.4.2 Methods for Data Collection and analysis

The research was initiated with an intensive study of GCP's drought tolerant rice research project-related documents, including research papers, annual reports, project briefs and working papers. From this, key actors (institutional and individual) were identified. Then, a 14-week (April-July, 2012) fieldwork in India and the Philippines was organised by the first author. In the Philippines, IRRI was visited and several rounds of interviews with the project leader and other scientists conducted. In India, the author visited and stayed at all the associated institutes (Footnote 11), attending meetings (including with farmers), discussing issues at length with scientists (as well as with directors/vice-chancellors), interacting with (masters and doctoral) students, addressing scientists in an interactive session and finally compiling a large number of participatory observations. A total of 45 in-depth interviews with the scientists, directors and others were conducted. Nevertheless, when it became apparent just how integral were the farmers to this knowledge production system, it was deemed necessary to engage in further fieldwork, with the aim of talking to them to gain a more holistic understanding of operation of the system. Thus, a second round of fieldwork focusing exclusively on the farmers was conducted, in the following October and December.

Every institution in this rice research network has its own local farmers' group, the size and composition of which vary. Scientists usually conduct their Participatory Varietal Selection (PVS) experiments with these groups, and sometimes the groups also help in seed multiplication and field-level demonstrations. It was not practically possible to study farming communities from all the institutes, so we decided instead to concentrate on the communities associated with just one institute, CRURRS, at Hazaribagh, in the state of Jharkhand.

There, the first author visited three different farming communities situated in three different districts. In each farming community, informal talks were held with a total of around 100 farmers (including women). Then, a total of 45 farmers were interviewed in-depth (only farmers who participated in the CRURRS research activities were observed/ interviewed). Several focussed group discussions (FDGs) were held in each farming community, with no scientists from CRURRS present. These informal talks, in-depth interviews and FDGs came to constitute the primary data source. Methodologically, therefore, this research was mainly qualitative, the aim being to understand the process of knowledge production.

Insights from the knowledge production literature that is elaborated in Section 3.2 is applied to analyse the data. The literature on knowledge production identifies five organising principles such as spatial dimensions of knowledge production, disciplinary orientation, involvement of end-users in the knowledge production process, validation of produced knowledge by the end-users and the market orientation of knowledge production. These five principles guided as descriptive models to guide the data collection, further data was placed within these five themes to identify how the knowledge production of GCP drought tolerant rice research is evolving and particularly which direction (non-instrumental or instrumental) it is inclined with. Data analysis was done simultaneously in the field during data collection as new perspectives from the field also gave directions for further observations and interviews. For example, it was assumed from the literature review that the GCP drought tolerant rice research network was created by the GCP; however, it became clear during the field that the network has existed for last 20 years. Therefore, the history of the development of this network was studied to identify the metamorphosis of this network as it exists today that is again analysed under the Spatial and Place based dimensions of knowledge production: the networked structure and internal dynamics.

3.5 FINDINGS AND DISCUSSIONS

3.5.1 Spatial and Place based dimensions of knowledge production: the networked structure and internal dynamics

The activity of GCP drought tolerant rice research is organised among fourteen different institutions and locations.[11] In addition to IRRI, the other institutions comprise Indian Council of Agriculture (ICAR) research institutes (a huge network focussed on several crops throughout India, unique among other NARS), state agricultural universities, NGOs and transfer-of-technology centres. These are situated in different agro-ecological zones, and all well within the purview of drought prone areas. GCP awarded four projects (summarised in Table 3) between 2005 and 2014 and has produced multiple, documented outputs, both in the form of drought-tolerant varieties – released by the Indian government for commercial cultivation (e.g. Sahbhagi Dhan, Shusk Samrat, Anna R(4) and ARB-6) – and publications (Kumar et al. 2008, Kumar et al. 2012a, b, Mandal et al. 2010, Verulkar et al. 2010, CGIAR Generation Challenge Programme 2009b, 2011). This GCP drought-tolerant rice research further employs a structure of research collaboration that is built upon two distinct networks developed according to different research angles and institutional settings: the Upland Rice Shuttle Breeding Network (URSBN), for rainfed upland, formally launched in 2003, and the Drought Breeding Network (DBN), for rainfed lowland, formally launched in 2005.

These two research networks were not created by the GCP. In fact, their formations were the results of long and complicated histories of institutional initiatives going back to the early 1990s. These began when the Rockefeller Foundation (RF) took the initiative to improve the rice crop with a major focus on drought tolerance in 1990s. At that time, the importance of drought was not appreciated within the ICAR mainstream, and anyway, it did not have the capacity to deal with this. According to one scientist, 'Understanding drought research was a visionary step for Indian agriculture by the RF'.[12] RF's initiative led to the formation of the International Rice Biotechnology Network (IRBN), and also to the Asian Rice Biotechnology Network (ARBN).[13] Meanwhile, between 1988 to 2002, there were several projects on crop improvement, particularly

11 In India, Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur; Central Rainfed Upland Rice Research Station (CRURRS), Hazaribagh; Narendra Dev University of Agriculture and Technology (NDUAT), Faizabad; Birsa Agricultural University (BAU), Ranchi; Central Rice Research Institute (CRRI), Cuttack; Tamil Nadu Agricultural University (TNAU), Coimbatore; Barwale Foundation (BF), Hyderabad; University of Agricultural Sciences (UAS), Bangalore; Anand Agricultural University (AAU), Anand; Orissa University of Agriculture & Technology (OUAT), Semiliguda; Maharana Pratap University of Agriculture and Technology (MPUAT) Banswara; Vivekananda Parvatiya Krishi Anusandhan Sansthan (VPKAS), Almora; and Jawaharlal Nehru Krishi Vishwavidyalaya (JNKVV), Rewa; and in the Philippines, IRRI (Los Banos) (CGIAR Generation Challenge Programme 2011).

12 Interview, Interviewee 3, Bengaluru, IN, 19-23 June, 2012.

13 Interviews: Interviewee 1, Hazaribagh, IN, 2-4 June 2012; Interviewee 2, Hazaribagh, IN, 2-4 June 2012.

Chapter 3

TABLE 3 GCP RICE PROJECT ON DROUGHT IN INDIA

Axapta No ***Project***	**Lead Institute** **Principal Investigator** **Country**	**Trait**	**Partners**	**Start – End (NCE)**
G4005.69.01 *Developing and disseminating resilient and productive rice varieties for drought-prone environments in India*	IRRI Arvind Kumar India	Drought tolerance	IGKV, CRRI, CRURRS, NDUAT, UAS, TNAU, BAU, BF	Mar 2005 – Feb 2008 (Feb 2009)
G3007.05 *Detecting and fine-mapping QTLs with major effects on rice yield under drought stress for deployment (marker-aided breeding)*	IRRI Arvind Kumar Global	Drought tolerance	BAU, BF, CRRI, CRURRS, IGKV, JNKVV, NDUAT, TNAU, UAS–Bangalore, UoAl, YAAS	Aug 2007 – July 2009 (Dec 2011)
G4008.05 *Connecting performance under drought with genotypes through phenotype associations*	IRRI Arvind Kumar Global		IRRI, CIRAD, ARC/WARDA, BIOTECH, CRRI, TNAU, BAU	Jan 2008 – Dec 2010 (June 2012)
G4011.04 *Dissemination and community of practice for newly developed drought-tolerant QTLs pyramided breeding lines*	IRRI Arvind Kumar	Drought tolerance	CRRI, CRURRS, DRR, NDUAT	July 2011 – June 2014

ARC/WARDA: Africa Rice Center/ West Africa Rice Development Association
BAU: Birsa Agricultural University
BF: Barwale Foundation
BIOTECH: National Center for Genetic Engineering and Biotechnology
CIRAD: Centre de Coopération Internationale en Recherche Agronomique pour le Développement
CRRI: Central Rice Research Institute
CRURRS: Central Rainfed Upland Rice Research Station
CSU: Charles Stuart University
DRR: Directorate of Rice Research
IGKV: Indira Gandhi Krishi Vishwavidyalaya
IRRI: International Rice Research Institute
JNKVV: Jawaharlal Nehru Krishi Vishwavidyalaya
NagU: Nagoya University
NDUAT: Narendra Dev University of Agriculture and Technology
SUA: Sokoine University of Agriculture
TNAU: Tamil Nadu Agricultural University
UAS–Bangalore: University of Agricultural Sciences
UoAb: University of Aberdeen
UoAl: University of Alberta
UoMi: University of Missouri
YAAS: Yunnan Academy of Agricultural Sciences

in rainfed conditions, such as the Eastern India Rainfed Rice Project (EIRRP), Upland Rice Research Consortium (URRC), Eastern India Farmers' Participatory Breeding Project (EIFPBP) and Consortium for Unfavourable Rice Ecosystem (CURE), projects that were funded by several national and international organisations, such as the International Fund for Agricultural Development (IFAD), International Development Research Centre (IDRC), ICAR and IRRI. These all projects were led by IRRI and involved a variety of partner institutions (mostly those mentioned in Footnote 11). Since 2003, first with the lunch of URSBN and in 2005 with the lunch of DBN, the research has been organised around these two networks.[14]

With the inception of DBN in 2005, GCP entered to fund its first project for this network titled 'Developing and disseminating resilient and productive rice varieties for drought prone environments in India' along with a co-funder the RF. Since then, the GCP has been funding another four (DBN and URSBN) projects (see table 3) on drought tolerance rice development. The network currently (post GCP phase) funded mainly by the Stress-Tolerant Rice for Africa and South Asia (STRASA) programme that is a Bill & Melinda Gates Foundation (BMGF) initiative. Concerning the coordination of the two networks, the URSBN is now coordinated by CRURRS from the Indian side, and the DBN is coordinated by the CRRI. Although drought research networks existed long before the GCP came into existence, GCP funding was crucial in sustaining the network until the STRASA programme entered the picture.[15] Finally, it should be added, the funding from external sources that this network has enjoyed refers only to research: other financial requirements, such as the scientists' salaries and research facility and other ongoing costs are met by the respective institutions (i.e. ICAR itself). It is also ICAR that evaluates the projects undertaken by the drought research network, in which also attention is paid to the role farmers' groups play in conducting PVS in the various ecological zones and in disseminating the new varieties through PVS trials (see below).[16]

In addition to organisational history and the influence of funding agencies, the internal dynamics within this network also shape the forms of research collaboration that determine the social organisation of its knowledge production. Concerning the work culture within the research network, a majority of the interviewees expressed their sense that relations within the network are friendly and based on mutual interest and that everyone is treated equally. They stressed that there is no domination or imposition, that the overall culture of the network is democratic, based on debate and discussion, and that once scientists are given responsibilities, they choose how to conduct the research

14 Interview, Interviewee 1, Hazaribagh, IN, 2-4 June, 2012.

15 Interviews: Interviewee 1, Hazaribagh, IN, 2-4 June, 2012; Interviewee 2, Hazaribagh, IN, 2-4 June, 2012; Interviewee 6, Ranchi, IN, 6-8 June, 2012; Interviewee 7, Cuttack, IN, 15-18 June, 2012; Interviewee 8, Cuttack, IN, 16-18 June, 2012; Interviewee 5, Raipur, IN, 12-13 July, 2012.

16 Interviews: Interviewee 1, Hazaribagh, IN, 2-4 June, 2012; Interviewee 7, Cuttack, IN, 15-18 June, 2012.

themselves, without interference from the network.

In most cases, IRRI is the coordinating institution, submitting research proposals to the funding agencies. As it is easier and more convenient for IRRI to reach out to the partner institutes than for other Indian institutes; being led by IRRI is a pragmatic choice on the part of the network. On the Indian side, the coordinator is CRRI. Neither of the coordinators behaves in an autocratic way, with due credit and proper recognition being given to all the members of the network. Regarding funding distribution, the major part is reserved for the CGIAR institute, in this case, IRRI. The scientists communicate with each other regularly through personal visits as well as email and Skype.[17] As a project leader, Dr Kumar also regularly visits all the different locations and partner institutes to observe the experimental work.[18]

Summarising, the GCP inherited an evolving network that had been in place long before it was established. Through repeated interactions between various institutions (RF, IDRC, IRRI, IFAD, etc.) and the growing awareness of the enormity of the drought problem in rice cultivation, a social space was created to apply an instrumentalist approach into the breeding research agenda (through the various institutions). The RF and then IRRI initiatives – in collaboration with other funding agencies – of delivering breeding material to these various researchers have together enabled the development of a network of scientists and facilities housed in different ICAR institutions for a kind of *fluid, hybrid, networked institutional setting, beyond the actual institutions*, in which the various individual spatial settings blur into one another. This organisational arrangement, or dynamic, seems to be based on a strong consensus about research perspectives and trajectory, yet rather loosely structured, non-hierarchical and democratic. The consensus on research trajectory – established through training and the deliverance of specific breeding material – is embedded within the bureaucratic organisation of their member institutions, such as IRRI and ICAR (Etzkowitz and Leydesdorff 2000, Gibbons, Limoges, and Nowotny 1994).

3.5.2 Societal context inclusion and validation: the involvement of farming communities as end-users

As end-users, the place of farmers and farming communities in and in relation to the network is particularly important to the instrumental paradigm of knowledge production. Aiming thus to consider the GCP rice-research network from a societal perspective, we posed two types of questions to farmers that use drought-tolerant

17 During an interview with Dr Kumar at IRRI, Los Banos, there was a call at his Skype from a network scientist, and he discussed the watering of the breeding lines at his station.

18 Interviews: Interviewee 1, Hazaribagh, IN, 2-4 June, 2012; Interviewee 2, Hazaribagh, IN, 2-4 June, 2012; Interviewee 6, Ranchi, IN, 6-8 June, 2012; Interviewee 7, Cuttack, IN, 15-18 June, 2012; Interviewee 8, Cuttack, IN, 16-18 June, 2012; Interviewee 5, Raipur, IN, 12-13 July, 2012.

varieties for cultivation, one type regarding the actual research process, which is often conducted inside the institutes, and the other about that part of the research conducted with their help through PVS. In respect of the former, we received unanimously negative responses. Every one of the 100 farmers questioned said that they do not participate and do not have the expertise to participate, and they are not interested in setting and do not set or want to set the agenda. In respect of PVS, on the other hand, we received almost unanimously positive responses. All the farmers questioned considered that they participate, are interested in their participation and have the expertise for this, while 87 of the 100 stated that they were being sponsored (paid) for their participation.

The research results indicate that, firstly, farmers do not have any interest in contributing to the research activities that go on inside the institute; they tend not to possess the academic skills, expertise or language skills, especially in English, to contribute to the research activities, and they neither want to be part of the research agenda setting for the institutes nor have they ever expressed their opinion in agenda formulation of the institute. They are very happy with being involved in the research process only at a much later phase. In this respect, the investigation revealed that farmers and farming communities do generally participate in the PVS trials and field level demonstrations (FLD), and sometimes also in village seed programmes (i.e. the seed multiplication programme). They like it that their opinions are taken very seriously by the scientists during the PVS trials, and that these are usually fully sponsored by the institutes, making them willing to participate. Indeed, the farmers are compensated by the institutes when there is a crop failure, so the programme acts as a kind of price-support mechanism, guaranteeing their income, which would otherwise be at risk.

Most of the farmers hold the scientists in high regard and share very cordial working relations with them. Interestingly, however, they often disagreed with the scientists and also often modified the agronomic practices to their convenience. Farmers generally discussed these changes with the scientists, and they claimed that both sides learn greatly from each other, which was confirmed by several scientists. The farming communities mostly expected good varieties from the scientists, defined as varieties that would both withstand abiotic-biotic stresses and be productive. Farming communities are not interested in varieties that are not productive. The FGDs showed that they do not consider themselves as stakeholders in the research establishment, but they do see themselves as important actors in it.[19]

Contrary to the instrumental paradigm of knowledge production, which, unlike the non-instrumental paradigm, stresses society as increasingly guiding scientific developments, this investigation indicates that the end-users of new breeding materials (the farmers) do

19 FGD with Farmers, Koderma District, Jharkhand, 14 December, 2012; FGD with Farmers, Hazaribagh District, Jharkhand, 17 December, 2012; FGD with Farmers, Chatra District, Jharkhand, 18 December, 2012.

not really want to be part of the actual knowledge production process. Indeed, they are only included well down the (plant variety) developmental line (i.e. downstream), where their role in the scientific endeavour is primarily to provide a legitimising function (i.e. empirical testing). In this respect, farmers might be considered as outside the network (and hence not included in the consideration of internal dynamics, above). Against that, however, their PVS role is vital, however distant it may be from the initial stages of knowledge production.

In fact, PVS provides an arena in which two different knowledge systems – roughly, theoretical and practical – meet and actually shape each other, which is beneficial for overall agrarian knowledge systems. In PVS, sensory evaluation is also made by the farmers regarding the cooking quality of the rice.[20] Thus, PVS operates through farmers at the level of variety performance (and rice quality), as determined not only verbally through interaction with the researchers but also in action, by farmers' dissemination, related extension activities and seed multiplication and sale. Moreover, researchers stress that their research is largely validated precisely when their varieties are accepted and used by farming communities. While this case-study may seem to undermine or be somewhat distant from the instrumental paradigm in terms of societal inclusion (since farming communities are only involved at the downstream end of research), therefore, it perfectly expresses the argued tendency for science to be ultimately determined as good or otherwise by society at large rather than scientists themselves.

3.5.3 Commercialisation or market orientation aspect of GCP drought tolerant rice research

In order to understand market orientation of the GCP knowledge production, we reflect firstly on the motivations of scientists for working on the GCP rice research network. To begin with, it should be stated they do not derive any direct financial benefit from this engagement. They are not paid or otherwise materially remunerated in any way. Actually, all the scientists from the Indian partner institutes in this network are employed by the state. As a condition of employment, they are required to conduct research and teaching activities, but doing research through a network is not necessary. Scientists can perfectly well maintain themselves within the system without doing any external research, and those involved in the network – often referred as an externally aided programme (EAP) – do devote a certain amount of their time to it.

For many of the scientists interviewed, doing research through this network brings them good breeding material, largely from IRRI, which has a particular value insofar as they view Indian breeding materials as somewhat inferior. Two scientists we talked

20 Interviews: Interviewee 12, Hazaribagh, IN, 4 June, 2012; Interviewee 13, Los Banos, Philippines 8 May, 2012.

to disagreed with this, maintaining that Indian breeding materials are equally good and substantiating this with the fact that most of the varieties in the farmers' fields in India were, in fact, developed from Indian breeding lines.[21] Apart from the acquisition of good breeding material, the reasons scientists gave for their involvement in the network included the international exposure it brings them, recognition within the scientific community, possibilities for peer reviewed publications, an opportunity to improve their English language and statistical analysis skills and intellectual satisfaction. For some, it also provided an opportunity to develop infrastructure for their home institute; through the GCP project, for example, CRURRS has obtained a $2000 rainout screening facility and a root scanner. Finally, for many scientists, doing research through the network is a way to help the farmers.[22]

It can be concluded that scientists working within the GCP research network are primarily interested in the immaterial benefits it brings them (with any material benefits going only to their home institute). Unmotivated by personal material gain, therefore, the ownership of research products developed within the network is not claimed by individuals in the network. Clearly, this takes place within a broader cultural environment whereby plant varieties are not primarily regarded in property terms affording opportunities for profit for their developers. Thus, although patenting and the acquisition of IPRs are encouraged by ICAR, no-one in the network is really interested in getting their product patented. In the case of variety development, the principle breeder (scientist) registers the variety in his name at National Bureau of Plant Genetic Resources (NBPGR), which is a kind of recognition but does not prevent anyone from using it for further development and cultivation.[23] Hence also, there is no competition among the scientists within the network, who generally work in a spirit of cooperation and collaboration for a collective goal in which the private motivations are largely professional and the public motivations are social, not material.[24]

The market and commercial orientation of the instrumental paradigm, it appears, is not very relevant in this case. Although the institutional environment does formally encourage scientists to apply for patents, property rights and licencing, in the context of this fluid, hybrid supra-institutional network, that does not occur. The products of

21 Interviews: Interviewee 6, Ranchi, IN, 6-8 June, 2012; Interviewee 14, Ranchi, IN, 6-8 June, 2012; Interviewee 10, Ranchi, IN, 6 June, 2012; Interviewee 4, Coimbatore, IN, 25-26 June, 2012.

22 Interviews: Interviewee 1, Hazaribagh, IN, 2-4 June, 2012; Interviewee 2, Hazaribagh, IN, 2-4 June, 2012.

23 Interviews: Interviewee 3, Bengaluru, IN, 19-23 June, 2012; Interviewee 5, Raipur, IN, 12-13 July, 2012; Interviewee 6, Ranchi, IN, 6-8 June, 2012; Interviewee 7, Cuttack, IN, 15-18 June, 2012; Interviewee 9, Los Banos, Philippines 2-4 May, 2012.

24 Farmers are free not only to multiply but also to sell the seeds, and thereby to realise their added value as a financial input informally reciprocating their output in time (which, as noted, is essentially risk free, since the costs of failed lines are born by the network). Since they are not really involved in the upstream development, however, the end-user benefit here does not influence the scientific process.

the research are made accessible to all, they are not commoditised. At the individual level, voluntarily engaged researchers are most motivated by immaterial individual goals related to their professional development – linked to which, indeed, is inquisitiveness (to do better science, as emphasised in the non-instrumental paradigm). The instrumental paradigm is clearly supported insofar as the network is product-oriented, but, after professional development, it is helping farmers (social causes) and also supporting institutional infrastructure (perpetuating science) that motivate researchers and thus defines the actual operation of the network, not commercial considerations.

3.5.4 Disciplinary orientation of GCP drought tolerant rice research

To reflect on the ways in which disciplinary orientation takes form within this GCP rice research network, we investigated the scientific research approach of the network. This was shaped by two factors: first, the presence of drought as an uncertain phenomenon and the scientific strategy applied to deal with this; second, the presence and development of many drought tolerant varieties that are uncultivated because farmers do not like varieties with low yield potential.[25]

It is known that drought is a very uncertain phenomenon in terms of occurrence, stage and intensity. Because of this inherent complexity, the network needed to develop a particular scientific strategy and vision with which to do drought research and then operationalise that strategy within the research network of the ICAR. In developing this strategy, consensus was reached on the following three issues. First, it was agreed to take grain yield as a primary consideration, with comparison of yields in both stressed and irrigated conditions. This became the basic principle for subsequent breeding activities. Second, the need was recognised to check the developed breeding lines at different places and at different levels of stress conditions to investigate the effect of the various locations on the reduction of grain yield. This was a scientifically difficult job because the genotype-environment (G*E) interaction is different in different places; in order to reduce environmental effects, breeding lines either have to be grown year after year or by carrying out multi-locational trials. Third, the network decided to go ahead with these multi-locational trials in its various agro-ecological zones.[26] At that time, multi-locational trials was not an option available even within ICAR, and even within the auspices of the All India Coordinated Rice Improvement Programme (AICRIP), only five trials in two to three locations were possible, compared with the many locations and much larger trial numbers that were required.[27]

25 Interviews: Interviewee 5, Raipur, IN, 12-13 July, 2012; Interviewee 3, Bengaluru, IN, 19-23, June 2012.
26 Interviews: Interviewee 5, Raipur, IN, 12-13 July, 2012; Interviewee 9, Los Banos, Philippines 2-4 May, 2012.
27 Interview, Interviewee 7, Cuttack, IN, 15-18 June, 2012.

Consensus was reached on these three issues during the annual review and planning meeting and a complex, scaled-up system of trialling was organised to improve varieties to become drought and also disease resistant. Accordingly, crosses are now made mainly at IRRI and other institutions, and then breeding material collected from all the different partners at CRRI. Off-season multiplication is performed at CRRI, and all the different breeding material is then sent back to different partners, including IRRI. The procedural consensus means that the breeding material from CRURRS goes to all the partners, and vice versa. Generally 300-400 initial breeding lines are tested through Observation Yield Trials (OYT) in all the locations, in both irrigated and stressed conditions. Those lines that perform well in both irrigated and drought conditions are then tested in Advance Yield Trials (AYT), which generally comprise 50-70 lines. After AYT, 10-12 promising breeding lines are nominated for the AICRIP trials, and these 10-12 promising breeding lines are then evaluated in the farmers' fields, through PVS.[28]

Alongside the (non-academic, extra-disciplinary) participation of farmers groups in PVS (described above), the research network is also characterised by the involvement of a range of disciplinary activities in the development of the drought-tolerant rice varieties. These disciplinary activities include field screening (phenotyping), genotyping (often with advanced level molecular and biotechnological tools), screening (for disease and pest resistance), associated breeding activities and, of course, conducting the PVS. In order to perform all these activities, the network comprises of a high number of breeders, comprising professionals across several disciplines. These fall into such categories as plant breeding, genetics, physiology, pathology, entomology, biostatistics and social sciences. Each step of disciplinary input into the breeding activities is essential for the next, so each discipline actually works in a way that is interconnected with others to produce knowledge related to drought resistance.

The investigation of this research network indicates, however, that the research approach of this network is still very much embedded within the disciplinary structure of modern science, leading to a kind of integration among these disciplines. Therefore, we conclude that the research network is rather interdisciplinary than really transdisciplinary, one in which the non-scientific actors are only involved at a peripheral stage while the scientific research is still guided by strongly disciplinary frames of references (Maasen, Lengwiler, and Guggenheim 2006, Repko 2008).

3.6 CONCLUSIONS

In this paper, we have aimed at understanding the knowledge production process of GCP, specifically by exploring GCP's drought tolerant rice research programme in

28 Interviews: Interviewee 9, Los Banos, Philippines 2-4 May, 2012; Interviewee 10, Ranchi, IN, 6 June, 2012; Interviewee 11, Coimbatore, IN, 25 June, 2012

the Indian context. To do so, we have taken insights from the literature on knowledge production to derive certain organising principles of knowledge production and used these (the differences between the two types of knowledge production) in presenting our empirical findings. In this section, first, we will reflect on those findings to elaborate on the type of knowledge production that has evolved in this case; and second, we will look at the implications of this specific type of knowledge production for larger agricultural research and development.

In the light of the findings presented, it can be said that the knowledge production in this GCP drought-tolerant rice-research case conforms neither to non-instrumental paradigm nor to the instrumental paradigm in absolute terms. It can be concluded that the knowledge production that has emerged in this case is hybrid in nature, with certain elements from both the paradigms present and some elements that belongs to neither of these two paradigms, in the following way.

As far as the place and space and utility of knowledge production is concerned, this case follows an instrumental paradigm, as knowledge production is organised in an extended research network focused on solving a specific societal problem (drought). This GCP drought-tolerant rice research network has evolved through repeated interactions between an extended list of institutions over a considerable period of time (Thune and Gulbrandsen 2011), and what evolved was not a single institution directing research, but rather the hub of a supra-institutional organisational entity. It is also argued that, within instrumental paradigm, knowledge production is carried out in non-hierarchical, heterogeneously organised forms that are essentially transient (Gibbons, Limoges and Nowotny 1994). This case adds empirical evidence to that proposition, as characterised by the specification of a fluid, hybrid research network. Within this hybrid institution, organisation practices are different from those of the original institutions from where the contributing scientists come (their employers). Indeed, with this type of knowledge production, actual institutional spaces are blurring into each other and creating an institutional hybridisation (Etzkowitz and Leydesdorff 2000, Etzkowitz 2001). Within this rearrangement, research is very loosely structured, strikingly democratic, non-hierarchical and based on consensus building. We conclude, therefore, that a loosely structured democratic institution can emerge and operate within a very structured and bureaucratic organisation, such as ICAR or CGIAR, or a combination of such.

Regarding the commodification and commercialisation of research – an essential feature of instrumental paradigm – this case has indicated an opposite trend, with an example outside the context of commodification through the acquisition of patents, the dominant trend in the contemporary scientific establishment (Atkinson et al. 2003, Purkayasthsa 2011). At a time when the whole patent and IPR paradigm is being severely criticised for confining science to a select few (Heller and Eisenberg 1998), this case shows that there are many researchers who clearly take the position that everybody ought to enjoy an equal right to the benefits of science, since they freely (and voluntarily) work for that. They take an ethical, humanistic stance, advocating that science has a role to play in making life better for the underprivileged and disenfranchised, and, thinking specifically of agriculture, for the resource-poor population at large. The products of the rice research network are open to all who want to use them for cultivation and further research and development. In this sense, the knowledge production of GCP drought-tolerant rice research conforms to non-instrumental paradigm in which science is not seen from a commercial perspective.

As far as the disciplinary orientation of this research network is concerned, in which the non-instrumental paradigm applies a disciplinary (or mono-disciplinary) approach and instrumental paradigm advocates for a transdisciplinary approach (Funtowicz and Ravetz 1993, Gibbons, Limoges, and Nowotny 1994), this case illustrates an example of the former. The GCP relies upon a range of specific disciplines for its perspectives, insights, data, concepts, theories and methods in the process of developing an interdisciplinary understanding of the drought problem that involves the perspectives and expertise of several disciplines. In the GCP rice project, we see different disciplines working together to understand the scientific as well as implementation complexity of the drought problem; but this represents a disciplinary integration that does *not*, in our opinion, transcend disciplinary boundary. As a matter of fact, complex scientific problems (such as drought) often requires the application of advanced cutting edge science (such as the application of molecular markers) that is embedded strongly in a particular disciplinary structure, unlike the transdisciplinary approach, which mobilises a range of theoretical perspectives and practical methodologies to solve problems that are not necessarily derived from pre-existing disciplines or formative of new disciplines. Overall, in this case, it can be concluded that disciplinary orientation does not strictly conform to either paradigm; however, given the dominance of several disciplines and its integration process, it is more inclined towards the non-instrumental paradigm.

Regarding the inclusion of end-users (involvement of society) within the knowledge production process – an essential feature for the instrumental paradigm, unlike the non-instrumental paradigm, in which science is guided by the scientific establishment alone (Gibbons 1999, Gibbons, Limoges, and Nowotny 1994, Gibbons 2000) – this case showed that the end-users (farmers) are involved not as an upstream stakeholders but as an extended community at the peripheral level to eventually judge, use and validate the scientific products. This research has shown that farmers are generally little interested in or capable of guiding science at the upstream end of development. Confronted with the presentation of drought as a complex scientific problem that requires the application of advanced cutting-edge science, the farmers see no role for themselves in formulating the agenda. Therefore, it can be concluded that, in this matter, this case certainly does not follow a non-instrumental paradigm, but that it does not follow an instrumental paradigm either (Kurek, Geurts, and Roosendaal 2007), as the end-users (farmers) are only involved in legitimisation of scientific research and not as a serious stakeholder steering or guiding science as claimed in the instrumental paradigm.

This brings us to the final organizing principle of knowledge production, concerning the change-over to validation of scientific knowledge by interested parties and society at large in the instrumental paradigm from the non-instrumental paradigm peer-community validation (Funtowicz and Ravetz 1993, Gibbons 1999, Gibbons, Limoges, and Nowotny 1994). Indeed, the analysis presented here shows that validation of research product was not only done by the scientific community (academically trained experts) but also by the end-users, the farmers as practitioner experts. The fact that the validation of scientific research is increasingly performed by extended peer communities or end-users at large does not in itself undermine the role of scientific validation as performed by the scientific community, of course. For example, research proposals awarded by GCP are basically evaluated by members of this group. Scientists often write research articles that are also reviewed by a fellow scientist. Therefore, as claimed by the instrumental paradigm, validation by an extended peer community has not replaced the scientific validation process or methods, but has rather supplemented and extended it. *Scientific community validation* still is very important for the scientific community, but increasingly in a way that *acknowledges the importance of extended peer community evaluation.*

What are the implications for this hybrid mode of knowledge production for agricultural research and development? The following three general implications are suggested as potentially useful for agricultural R&D organisations such as NARS and CGIAR. First, given the typically entrenched scientific bureaucracy and top-down approach of other NARS, this case can serve as an example of creation of institutional space in which scientists pursue innovative research along with several other organisations that can complement the research scope of NARS, as in this case we saw that the drought-related research was initiated long before ICAR had the capacity to do engage in this. Second, when researching complex scientific problems, such as drought, salinity or submergence, conducting the research within an agro-ecologically diverse set-up can help in understanding complexity (the different manifestations of drought in different places) and providing structural restriction (to analyse and overcome the genetic and environmental interactions within a limited timeframe). In this way, the changing network organisation also changed its functioning. It should be noted here also that through this network, the sharing of breeding material is conveniently taking place without any legal obligations such as Material Transfer Agreement (MTA) or proprietary obligations.

Third, the most important lesson that can be discerned here concerns the involvement of farmers within the knowledge production process at the peripheral level through PVS. PVS is an arena where the scientific and farming communities materially interact with each other and one that offers possibilities to tailor or attune technology for context-defined specific needs, an arena where technology is negotiated and disseminated. It thus manifests a middle-ground route that allows a negotiated approach beyond the black-and-white acceptance-versus-rejection of the technology debate (Ruivenkamp 2005, 2008). PVS can also be seen an arena that reduces the gap between the development of a technology and its adoption.

PVS as it is practised has been criticised in an earlier study (Misiko 2013), however, in this study farmers and scientists informed that PVS helps in a direct manner in three different ways. First, if the breeding lines perform well in farmers' fields, then it supports dissemination of the variety as well as in its adoption; it also helps in farmer in respect of farmer extension activities. Second, PVS assists seed multiplication; in particular, farmers can (and do) access the seeds of a new variety before the national government officially decides on its dissemination and seed multiplication, and they can (and do) also sell the seeds of the new varieties to fellow farmers. Third, scientists receive feedback from the farmers; this is an arena in which two different knowledge systems – roughly, theoretical and practical – meet and actually shapes each other, which is beneficial for overall agrarian knowledge systems.

Chapter 4

The emergence of a commons-based peer production (CBPP) mode in an international agricultural research network: the case of Generation Challenge Programme (GCP)

ABSTRACT

The characteristics of commons-based peer production (CBPP) have been studied within systems of information production as mediated by information and communications technology (ICT), such as free open source software (FOSS) and Wikipedia. The organisational attributes of the CBPP mode applied in computer software production include the modulation of work, small-size granularity of components, and mechanisms that integrate these modules into an end-product. Socio-economically, this form of production is based on cooperation, collaboration and collective action rather than property, contract and managerial hierarchies. This article presents the results of an investigation into whether and how these CBPP mode characteristics emerge and/or are applied in the rice research network (RRN) of the Generation Challenge Programme (GCP). The GCP is an international agrarian knowledge production network that aims at reconciling upstream research with downstream development. This paper argues that a complex and extended form of CBPP has emerged within the knowledge production of GCP-RRN. Further, this paper elaborates on the implications for an extended form of CBPP in international agricultural research.

Keywords: CBPP; Knowledge Production; Research Network; GCP; Drought; India

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4.1 INTRODUCTION

The production of free and open source software (FOSS) takes place in a decentralised manner generally constructed in a more-or-less informal and loosely structured way. There is no compulsion to participate in these projects, but people do participate for a variety of reasons, such as the pure pleasure of creation, a particular sense of purpose, for a social cause, to satisfy psychological needs, to build social relations for a common purpose and to create certain sense of belonging. Benkler (2002, 2006), while analysing the production of FOSS, argues that *a new production system is emerging*, based on cooperation, collaboration and collective action. He characterised this new (ICT) production system emerging in software industry as the commons-based peer production (CBPP) mode that has already produced 'some of the finest software, the fastest supercomputers and some of the best web-based directories and new sites.' Benkler has also argued that CBPP can infuse certain moral and political values such as democracy, social justice and autonomy (Benkler 2002, 2006, Benkler and Nissenbaum 2006).

Most CBPP studies have been *limited in scope*, confined, that is, within the purview of exclusive peer production phenomena in the software arena and/or taking a *single perspective* on the economic aspects of CBPP (in terms of efficiency, productivity and its potential superiority over market-based production systems) (Landini 2013, Mansell 2013, Meng and Wu 2013, Schmidt 2012, Gillespie 2013).[29] In this paper, we aim to study CBPP with a special attention to non-economic aspects, particularly to the ways in which the CBPP mode is socially organised in respect to a software/hardware combined production system. Therefore, our study focuses on the international networks of agricultural research, representing a production that contains both software (genetic traits) and hardware (the agricultural crops) (Dedeurwaerdere 2012). [30]

To do so, we explored the drought-tolerant rice research network (RRN) of the Generation Challenge Programme (GCP). The GCP's knowledge production is focussed on the construction of international research networks and communities of practice where diverse sets of actors, both individual and institutional, with various capacities contribute in a multi-layered way towards developmental outcomes (Vroom 2010). In this sense, GCP reflects certain characteristics of a new social organisation of

29 An exception is the study by (Kostakis, Fountouklis, and Drechsler 2013), which studied the case of the Helix-T wind turbine as a physical product comprised both of hardware and software.

30 Of course the computer software developments (may) result in products too, but there is an important sense in which the software *is* the product and what follows in the way of hardware is further to rather than integral to the initial (software) development, whereas in the agrarian case we can more clearly and profoundly distinguish (say) new genetic codings and the seeds/varieties they 'inform' as both products in themselves that are yet part of a single, integrated production process, in which the development of the former, that is, is not just a part of but also crucially (teleologically) aimed at that of the latter.

agrarian knowledge production with some apparent similarities to the CBPP mode in the software arena (Benkler 2006). The following research question guided this study: *how and to what extent does the GCP drought-tolerant rice research embody the CBPP mode? And what are its implications for wider CBPP and agrarian knowledge production debate?*

This is important for two reasons: firstly, it adds to the theoretical discussion on CBPP especially when the product is outside the ambit of ICT mediated production system; and secondly, by reflecting on the concrete practices of agrarian knowledge development of GCP-RRN, it can indicate to the possibilities of non-proprietary knowledge development as over the last few decades many have criticised the pervasive nature of intellectual property rights in agricultural research as confining knowledge sharing, leading to a separation of the (institutional) knowledge development from the local context of agriculture and ultimately deterring innovation (Atkinson et al. 2003, Heller and Eisenberg 1998, Ruivenkamp 2005, Kloppenburg 2010a). Therefore, by reflecting on the concrete practices of knowledge development within the GCP-RRN, the research aims to deliver insight whether a CBPP model can be applied in the context of international agricultural research to link towards a more inclusive, shared and better connected forms of agriculture (Louwaars 2007, Pretty 2002, van der Ploeg 2008, Falcon and Fowler 2002, Kloppenburg 2010a, b).

This article is divided in five sections. Following this short introduction, we first outline the characteristics of the new social organisation of production in the software arena, with reference to the work of Benkler. In the third section, we elaborate the methodology applied for this research along with the description of the research site. After that, the empirical findings of the investigation of the RRN are presented, referring to the organisational re-arrangements of the CBPP mode in the software arena. The fifth section concludes by reflecting upon the findings and further indicates some implications.

4.2 SOCIAL REORGANISATION OF PRODUCTION THROUGH THE CBPP MODE

The concept of CBPP was coined by Benkler (2002) when observing the trends of free and open source software production through the internet. Referring to processes such as the development of Linux kernel, Benkler perceived the emergence of a new mode of production, which he showed to be based on an *organisational innovation*. This new mode was identified in terms that can be analysed as comprising three main structural attributes.

First, the software was produced through a system of components or modules, each independent of the others. The new mode of production, therefore, involves a *modularisation of work*, enabling production to be incremental and asynchronous, pooling the discrete efforts of different, importantly unconnected (autonomous) individuals with different capabilities working at different times and places. Second, in order for a modularised work to pool successfully a relatively large pool of contributors, the modules were predominantly fine-grained, or small in size. The *granularity of the modules or components* thus becomes a characteristic feature of and crucial to the new mode. It is the variable but especially small size of a project's modules that allows it to capture the efforts of those whose levels of motivation and/or access to resources are insufficient to sustain anything more than quite small contributions. Heterogeneous granularity in the software arena, therefore, refers to this accommodation of relatively large numbers of variously but especially small-grained contributions, allowing people to collaborate according to their commitment/resources (Benkler 2002, 2004, Benkler and Nissenbaum 2006).

Thirdly, Benkler observed that the various individual efforts were integrated at low cost in order to realise open source computer software developments as a common objective. Thus develops a successful peer-production, with mechanisms by which the modules (components) are *integrated into a whole end-product*. This is particularly important since the peer production mode assumes (starts from) a decentralised organisational base, in which the authority to act, residing with individual agents with opportunities for action, is no longer hierarchically structured; there is often no leadership or only a leadership that is perfunctory and not based on the wielding of any power to limit other activities. Related to this decentralised form and thus to the need for integration is the characteristic of volunteerism, since individuals participate freely, without any compulsion, and for a number of quite different reasons, ranging from the pure pleasure of creation through a particular sense of purpose to the companionship and social relations that grow around that peer production mode. Equally, instead of direct payment, contributors work for indirect rewards, both extrinsic (enhancing reputation and developing human capital and social networks) and intrinsic (satisfying psychological needs and providing pleasure and a sense of social belonging). Thus, the peer production mode uses social cues and motivations rather than prices or commands to coordinate the action of participating agents (Benkler 2002, 2004, Benkler and Nissenbaum 2006).

This mode of production demands a type rather than level of commitment of its participants, namely, to a particular approach and/or objective of a particular community in which the participants are engaged. The commitment required relates to values, an ethos, which links to the fundamental, *non- proprietary* aspect of this peer production, its basis in the common, as a common effort. No single entity holds exclusive rights to organise the production efforts, and this extends to ownership of the end product. Instead of exclusive property and contracts, therefore, peer production uses legal innovations (like the GNU General Public License and creative commons) and the organisational arrangements (above) to direct usage, as well as behavioural norms and technological constraints on antisocial behaviour. (Benkler 2002, 2004, 2006, Benkler and Nissenbaum 2006).

4.3 METHODOLOGY

Following other research on CBPP (Kostakis, Fountouklis, and Drechsler 2013, Meng and Wu 2013), a single case study method (Yin 2009) is applied to provide in-depth insights in the emergence of a renewed social organisation of the GCP-RRN knowledge production.

The analysis started with an exploratory study of the GCP-RRN by studying the necessary documents (annual reports, published papers, project briefs, working papers, research articles, project updates, etc.). From this analysis, we identified all the different institutional and individual actors associated with this research network. The network has already produced several research papers (such as (Kumar et al. 2008, Mandal et al. 2010, Verulkar et al. 2010), and it has developed a drought-screening protocol and produced several drought-tolerant varieties (such as Sahbhagi Dhan, ARB-6 and Anna R(4)) released by the Indian government in the states such as Jharkhand, Chhattisgarh and Gujarat.[31]

The RRN encompasses thirteen institutes in India and the Philippines.[32] Nine of these (nos. 1-9 in the footnoted list) are state agricultural universities (SAU), mainly administered by federal states in India. The following three (nos. 10-12) come under the Indian Council of Agricultural Research (ICAR), in the Ministry of Agriculture (although BF [no. 12] is an Indian NGO). IRRI (no. 13.), which heads the network, is an international institute operating under CGIAR, as indicated. The network had four projects funded by the GCP between 2005 and 2014. These projects are: 1) developing and disseminating resilient and productive rice varieties for drought-prone environments in India, 2) detecting and fine-mapping QTLs with major effects on rice yield under drought stress for deployment via marker-aided breeding, 3) connecting performance under drought with genotypes through phenotype associations, and 4) dissemination and community of practice for newly developed drought-tolerant QTLs pyramided

31 One variety (Sahbhagi Dhan) has also been released under a different name in Nepal and Bangladesh.

32 1) Anand Agricultural University (AAU), Anand, 2) Birsa Agricultural University (BAU), Ranchi, 3) Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur, 4) Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Rewa, 5) Maharana Pratap University of Agriculture and Technology (MPUAT), Banswara, 6) Narendra Deva University of Agriculture and Technology (NDUAT), Faizabad, 7) Orissa University of Agriculture and Technology (OUAT), Semiliguda, 8) Tamil Nadu Agricultural University (TNAU), Coimbatore, 9) University of Agricultural Sciences (UAS), Bangalore, 10) Vivekananda Parvatiya Krishi Anusandhan Sansthan (VPKAS), Almora, 11) Central Rainfed Upland Rice Research Station (CRURRS), Hazaribagh, 12) Central Rice Research Institute (CRRI), Cuttack and Barwale Foundation (BF), Hyderabad, and 13) International Rice Research Institute (IRRI), Los Bonas.

breeding lines (CGIAR Generation Challenge Programme 2011).

To develop further insight into the network and its operation on the ground (literally, as well as figuratively), two rounds of fieldwork were conducted (by the first author, in April-July 2012 and October-December 2012). During the first round, the author visited all the partner institutes, starting with the IRRI establishment for the GCP rice research project. All the scientists involved in this project were interviewed several times. Spending considerable periods of time at the institutes enabled the author specifically to interact with the heads and also with masters' and doctoral students and generally to make practical observations. A total 45 in-depth interviews were conducted in this phase of the research. It also became apparent at this point that farmers' groups are also part of this network; in fact, all the institutions housed in the various agro-ecological bodies related to the network have their own (sets of) formally and informally associated farmers groups. For the second round of fieldwork, it was decided to interview the farmers group associated with the CRURRS, at Hazaribagh, in the state of Jharkhand, north-eastern India. Three farming communities situated in different districts around Hazaribagh and involved in this research project were studied by interview and observation. Around 100 farmers were informally engaged in this process and further 45 in-depth interviews conducted.

Benkler's theoretical model on CBPP as elaborated in Section 4.2 is employed both as descriptive model for data collection as well as analytical tool to identify the main themes from the field. Data was collected to find out how the modular approach to knowledge production is taking place within the GCP-RRN, how we find granularity within the GCP-RRN knowledge production, and finally how decentralisation and social cause as motivating factor for participating in the GCP-RRN are taking place. After coding these data, an important analytical tool was to compare the meaning of these themes as practiced within GCP-RRN with the ICT mediated software production. These comparisons helped in understanding the qualitative difference between CBPP mode in software and in this GCP-RRN case, and further helped in generating implications for agrarian knowledge production.

4.4 FINDINGS

The GCP-RRN today consists of the Drought-Breeding Network (DBN) and the Upland Rice Shuttle Breeding Network (URSBN) as the present results of a metamorphosis over several programmes of various institutions for the last two decades. Apart from the blending of various institutional research activities, a gradual shift also took place in respect of dominant funder institute. Originally, the RRN was funded by the Rockefeller Foundation (RF), increasingly in cooperation with IRRI, as one the CGIAR institutes; then the CGIAR GCP took the lead, which, in turn, has since been taken by Stress-tolerant Rice for Africa and South Asia (STRASA) – a Bill & Melinda Gates Foundation (BMGF) initiative. In this section, we present the results of the analysis of the functioning of the network and particularly the ways in which its knowledge production is organised. The findings are presented below indicating the dynamism in the institutional setting and social organisation of knowledge production of the drought-tolerant rice varieties.

4.4.1 The History of Institutional Evolution and Blending of Institutional Settings of GCP-RRN

Composed of many different institutions related to the DBN and URSBN and located in various agro-ecological zones in India as well as of individual researchers from these and other institutions, the RRN has evolved as a dynamic and fluid structure through a historically complex institutional process. Parts of this network were established by the RF in the 1990s, when it arranged first, for the training of young NARS scientists in advanced biotechnology and plant breeding research at various institutes in the US, and then, for their funding to continue advanced research in India upon their return, which eventually led to the formation of the International Rice Biotechnology Network (IRBN) and the Asian Rice Biotechnology Network (ARBN) (Interviewee 3, Bengaluru, IN, 19-23 June, 2012.), which, in turn, established connections with IRRI for further collaborative projects. Thorough this collaboration with IRRI, many scientists became part of a project called the Eastern India Rain-fed Rice Project (EIRRP), which was led by IRRI. EIRRP was funded by ICAR and the International Fund for Agricultural Development (IFAD). This was followed by the Upland Rice Research Consortium (URRC) conducted in Indonesia, Philippines, Thailand and India in three phases from 1991 to ’99. Most of the drought-tolerant varieties released through the project were initiated through the URRC (such as Sahbhagi Dhan) (Interviewee 1, Hazaribagh, IN, 2-4 June, 2012.).

In the meantime, around 1997-99, the International Development Research Centre (IDRC) funded the project Eastern India Farmer’s Participatory Breeding Project (EIFPBP). Farmer’s participation and participatory methodologies were introduced by this project. In 2001, the Consortium for Unfavourable Rice Ecosystems (CURE) was formed to study challenging upland and lowland rice conditions. The CURE programme focussed on three contemporary rice problems: drought, submergence and salinity. Research centers associated with the CURE programme in India are located at Hazaribagh, Raipur, Faizabad, Bangalore, Coimbatore and Cuttack. In order to conduct detailed drought research, Dr. Gary Atlin, leader of the drought programme, came up with the idea of forming a network with the partners of the CURE programme. Accordingly, in 2003, the URSBN was launched (Interviewee 4, Coimbatore, IN, 25-26 June, 2012; Interviewee 5, Raipur, IN, 12-13 July, 2012.).

The URSBN was initially funded through the core monies from IRRI. After successfully conducting the drought research for two years between 2003 and 2005, the need was felt for another similar network specifically focussing on rain-fed low land, which led to the formation of the DBN, in 2005. Since it was not possible for IRRI to support the DBN at that time, Dr. Atlin asked RF in Thailand and received initial funding to conduct breeding and associated dissemination activities. After some time, RF moved away from funding agricultural research in Asia (to concentrate instead on Africa), and GCP stepped in, having just started its mission to support research related to drought tolerance. GCP then funded the four research projects on drought tolerance within this network listed (above). Currently, this network receives substantial funding from the BMGF initiative STRASA. The project leader for all the projects is Dr. Kumar from IRRI, while CRRI (no. 12) is the network co-ordinator from the Indian side. A large chunk of the funding is allocated for IRRI, through whom all the technology-based upstream cutting-edge research is conducted. Indian institutes always receive less funding and are mainly involved in conducting field research rather than advanced level, cutting-edge laboratory work (Interviewee 1, Hazaribagh, IN, 2-4 June, 2012; Interviewee 2, Hazaribagh, IN, 2-4 June, 2012; Interviewee 6, Ranchi, IN, 6-8 June, 2012; Interviewee 7, Cuttack, IN, 15-18 June, 2012; Interviewee 8, Cuttack, IN, 16-18 June, 2012; Interviewee 5, Raipur, IN, 12-13 July, 2012.).

In fact, the historic shift in institutional funding leadership reviewed here has also implied and reflected a shift in the scientific disciplines considered the best suited to the search for solutions to the problems of drought. Originally, the network very much followed a plant breeding approach, with drought seen as a problem to be solved primarily by plant breeders through the development of drought-tolerant varieties. Other trajectories, such as rice intensification systems, received little or no attention. Gradually, however, paradigmatic adaptations have developed following a more agro-ecological and participatory plant breeding approach.

Since its inception, therefore this network has aimed to produce drought-tolerant rice varieties as an evolving, dynamic structure, constituted around several layers and with adjustments of strategy regarding methodology. Clear parallels to the organisation of peer production may be identified in respect of *development* (rather organic) and *flexibility* (unfixed form), although the input of institutions is quite different. In this regard, further to the organisational layering achieved at institutional level (the different roles of the various institutions), we should note also the range of institution size and type (involving international development agencies, national government and regionally oriented universities) and the fact that individuals do input labour voluntarily (see below). Although the institutionalised arrangements of the IRRI-headed and relatively well funded drought-tolerant rice research network are rather different from the essentially individualistic and resource-poor orientation of CBPP, therefore, there is an obvious similarity regarding overall *organisational dynamism and fluidity*.

4.4.2 The Emergence of Heterogeneous Research Entities and Research Approach of GCP-RRN

In order to study the complicated problem of drought, the RRN has organised itself through the establishment of several research institutions. The nine Indian university (ICAR-SAU) institutes (nos. 1-9 listed above) are relatively small and autonomous, so somewhat akin to the individuals involved in (the modules) of the CBPP mode of software development. This parallel is augmented by the network's internal work culture and the independence of the scientists involved (below) At the same time, however, large, powerful and distantly directing umbrella organisations are involved in guiding the network, especially the main funders (RF, IRRI, STRASA), as well as the GCP and also the Indian government, through the Ministry of Agriculture (Interviewee 1, Hazaribagh, IN, 2-4 June, 2012; Interviewee 7, Cuttack, IN, 15-18 June, 2012.). Thus, the RRN may be adjudged to feature both small modular knowledge development and large institution input, giving it a mixed granularity from the perspective of size that is rather different from the software case, but which does include an important fine grain element facilitating autonomy and commoning of the knowledge produced. The different research institutions are located, moreover, in different ecological zones, and within each ecological-specific institution, different combinations of scientific disciplines are brought together, such as advanced genomic science and comparative biology, biotechnology, plant science, plant physiology, plant breeding, statistics and social sciences.

Biotechnology and molecular markers are used to develop crosses in IRRI and other Indian institutes. These crosses or the materials are then sent to CRRI for off-season multiplication. After multiplication, the breeding lines are once again sent back to all the partner institutions including IRRI. The rice research network has tested some 300-400 initial breeding lines by observational yield trials (OYT) in both irrigated and in stressed conditions in all the locations (field sites). Of these, some 50-70 breeding lines that performed well have been further tested in advance yield trials (AYT), from which 10-12 promising breeding lines have been sent for PVS.[33] It is at this point that farmers enter the process, in the last layer of knowledge production, selecting those varieties they consider most attuned to their differentiated socioeconomic and agro-ecological conditions and thus practically able to increase their agricultural production. Generally, in any one area, there are three PVS trials replicated in 50 farmers' fields. The PVS trials of this network are gendered balanced, so there is equal participation from women. Sensory evaluation is also done to reflect upon the cooking quality of rice, the final (end-product) input into the knowledge production process (Interviewee 9, Los Banos,

33 Sahbhagi Dhan, Shusk Samrat, Anna R(4) and ARB 6.

Philippines 2-4 May, 2012; Interviewee 10, Ranchi, IN, 6 June, 2012; Interviewee 11, Coimbatore, IN, 25 June, 2012.).

From the discussions with farming communities it came out that farmers are interested in participating in the PVS trials as it brings them new and improved seeds. Moreover, the cost of cultivation is borne by the institute and the institute provides paid compensation in the event of crop failure. While the farming communities like to be involved in the downstream layer of the knowledge production, they do not show much interest in participating in the upstream research. PVS basically creates a social space between scientists and farmers to reflect critically on the use of science and technology for developing drought-tolerant rice varieties attuned to their local contexts (Focused Group Discussion with Farmers, Koderma District, Jharkhand, 14 December, 2012; Focused Group Discussion with Farmers, Hazaribagh District, Jharkhand, 17 December, 2012; Focused Group Discussion with Farmers, Chatra District, Jharkhand, 18 December, 2012.).

Within this agro-ecological specific and multidisciplinary constructed research institutes, the scientists contribute according to their expertise in combination with others, so intertwining, as it were, at the different layers of the knowledge production process at specific work sites. For example, breeders and biotechnologists both make specialist contributions to upstream breeding activities mediated through cutting edge technologies in the laboratory, while plant physiologists are much more involved in field screening, plant pathologists in building pest and disease resistance, back in the lab again, and statisticians in data analysis, in the office, and social scientists and farmers combine their efforts in field trials and for PVS (Interviewee 5, Raipur, IN, 12-13 July, 2012; Interviewee 9, Los Banos, Philippines 2-4 May, 2012.).

4.4.3 Internal Dynamics of GCP-RRN and Reasons for Participation

In addition to the organisation of the production of drought-tolerant rice varieties, there is a similarity to CBPP in respect of the *work culture* through which the scientists are motivated to participate in this network. Because the scientists involved in the RRN are already employed by their respective institutions to either conduct research or be involved in educational activities, they do not gain any personal material benefits by participating in the RRN. The employer institutions allow their scientists to direct part of their paid labour to the network through research activities carried out in or at (field) sites linked (geographically proximate) to the main site of employment (generally, the university institute offices and laboratories), but the labour given by scientists is also, nevertheless, a voluntary effort on their part, requiring an effort additional to their contracted or otherwise expected duties. The scientists choosing to participate in the network indicate a number of motivating reasons for giving their time and energy, including immaterial rewards, the social objectives, pragmatism and devotion to science (Birch 2012).

Some scientists expressed their motivation to participate in the network as derived from their receiving good quality breeding material, particularly from IRRI, because of their association in the network. Others expressed their doubts about the quality of the material for the Indian context and explained their participation because of the pleasure and intellectual satisfaction they gain from doing science. A number of scientists mentioned that the network because it helps them to gain international exposure, recognition within the scientific community, and possibility to publish research papers in peer reviewed journals. One scientist explained that working within the network also offers possibilities to enrich existing research infrastructure; for example, his institute got a rainout screening facility and a root scanner through the GCP projects. This was not a personal gain, however, of which we saw no evidence at all. We did encounter altruism, and this underlay a widespread motivation: in general, the scientists stated that they work in the network simply as a (direct, engaging) way to help farmers (Interviewee 1, Hazaribagh, IN, 2-4 June, 2012; Interviewee 2, Hazaribagh, IN, 2-4 June, 2012; Interviewee 3, Bengaluru, IN, 19-23 June, 2012; Interviewee 5, Raipur, IN, 12-13 July, 2012; Interviewee 6, Ranchi, IN, 6-8 June, 2012; Interviewee 7, Cuttack, IN, 15-18 June, 2012; Interviewee 9, Los Banos, Philippines 2-4 May, 2012.).

While the individual scientists in his/her formal working hours within the nine ICAR-SAU institutes (listed above, Section 4) are confronted with heavy scientific bureaucracy and top-down decision making, the informal work environment of the rice research network is characterised by an absence of scientific bureaucracy and top-down decision making. In the context of a work culture in which individual researchers participate freely on the basis of their own motivation, the internal dynamics are friendly and democratically based on debate and discussion. For example, during the annual planning and review meeting of a partner institute, all the members of the network give a presentation on the work they have done in the previous year and all the members are jointly involved in decide further planning for the coming year. There is no imposition or domination from either a senior member of the network or an assumed lead institution. This internal network freedom extends to working practices. The network does not interfere with individual scientists in respect of how they carry out their research, and it is through frequent communication among the various scientists that progress is made (Interviewee 1, Hazaribagh, IN, 2-4 June, 2012; Interviewee 2, Hazaribagh, IN, 2-4 June, 2012; Interviewee 6, Ranchi, IN, 6-8 June, 2012; Interviewee 7, Cuttack, IN, 15-18 June, 2012; Interviewee 8, Cuttack, IN, 16-18 June, 2012; Interviewee 5, Raipur, IN, 12-13 July, 2012.).

In fact, the rice varieties developed by scientists, plant breeders and farmers of this network are registered. Although ICAR supports patenting and IPR acquisition, registration is made at National Bureau of Plant Genetic Resources (NBPGR), with recognition as the sole purpose. The developed varieties or *breeding lines are open to all*, including farmers, who are free to multiply and sell the seeds to others (Interviewee 9, Los Banos, Philippines 2-4 May, 2012; Interviewee 3, Bengaluru, IN, 19-23 June, 2012). This all indicates that the participants of this network engage with the spirit of cooperation and collaboration for a collective goal and disregard opportunities for private appropriation. Clearly, there is a commons ethos pervading the enterprise.

4.5 DISCUSSION, CONCLUSIONS AND IMPLICATIONS

The findings presented above indicate that characteristics of the CBPP mode as investigated by Benkler for software are also present in the organisation of the knowledge production of RRN. Some aspects of this are similar; while others take different, extending forms (see below). In this section, we first summarise the findings along the lines of key organising elements of CBPP such as modularity, granularity, sharing of resources, decentralised organisation and immaterial or social cause for participation, and further we conclude the paper by showing some of the implications of the emergence of CBPP within the GCP agrarian research network.

First, we observed that the knowledge production of this RRN is organised in several institutions located in different agro-ecological zones. This geographically framed, disciplinary compartmentalisation of agrarian knowledge production reflects the modular approach of the CBPP mode. However, within the software arena – as explained by Benkler (2004, 2006) – the main goal of modularity is to divide the work between as many as possible groups so as to raise the number of people contributing to the production process. Conducting the knowledge production in different agro-ecological site is basically aimed at achieving two things: firstly, to reduce environmental effect within a comparatively less time; secondly, to incorporate local and context specific needs within the larger framework of technology development to attune technology (Ruivenkamp 2005, 2008, 1993).

As a result we have seen the same breeding line (Sahbhagi Dhan) has been released in several agro-ecological zones as a preferred drought tolerant variety. It has also been released in Nepal and Bangladesh as a drought tolerant variety in different name (Dobermann 2012). In the RRN, the modularisation of work stems from the very nature of the agrarian knowledge production, in which there is a material need for modularisation due to agro-ecological considerations. The modularisation here, of various work-sites and institutes located in different ecological zones, is related to the material requirement of establishing a linkage of a drought-tolerant rice variety to its environmental setting, for which each scientific discipline delivers its own specific contribution within the framing of a plant breeding approach.

This modular approach of knowledge production brings us to the debate on reconnecting agriculture with local needs (Louwaars 2007, Pretty 2002, van der Ploeg 2008, Falcon and Fowler 2002, Kloppenburg 2010a, b). This brings us to the debate on how to think about reconnecting agriculture with its local context. Above authors argued passionately the need for reconnection insufficiently dealing with how and in what way we should think about reconnection. Especially at a given time, when mostly agricultural research is taking place with cutting edge advanced technologies such as biotechnology or molecular technologies in a laboratory far from the farmers field.

From this case of RRN, we can plausibly state that the reconnecting debate on agriculture possibly starts with the way agrarian knowledge production is organised. But given the inevitability of cutting edge technology application, it seemed as elaborated in this case that at the upstream level in the laboratory, it is better to be disconnected as we have argued some other paper that local end-users are often not interested to involved in (Basu et al. Forthcoming) . However, as it is clear from the research approach of this network that after certain point of time at peripheral level through PVS local farmers and local contexts are included to attune the technology with its local needs. Knowledge production of this network actually created a space for negotiation and adaption of technology through PVS. This phenomenon of disconnection at an upstream level and creating space for reconnection at a downstream level is something that the modular approach of knowledge production can contribute to the debate of international agrarian knowledge production (Ortiz et al. 2008).

Second, while in the software arena the granularity of the modules is based on the different level of contribution of each individual participant, depending on his/her different level of capacity and motivation, which emphasises the small-scale of contributions, the RRN case is characterised by an extended heterogeneous granularity built not only on the differences in actor sizes/types (institutional, as well as individuals), but also in disciplines and ecological zone (and the inter-relationships of these) and, of course, in the resource origins (plants, DNA, within the plant breeding framing of the drought problem).[34] Thus, whereas heterogeneous granularity in the software realm is basically of one or two dimensions (individuals' capacity and motivation) and characteristically fine (small contributions), in the combined soft/hardware arena of agrarian production it is multi-dimensional (regarding institutions, disciplines and zones, as well as plants), and variably-sized, including fine-grain oriented. We may come to a similar heterogeneous, granular conclusion, therefore, but characterise software production in terms of small-scale heterogeneous granularity and the agrarian in terms of a multi-grained institutional,

34 Since (insofar as) computer software development importantly does not have a hardware component, then the classical (Benkler's) CBPP model has no equivalent to plants/DNA or the problem framing.

multidisciplinary and resource heterogeneous granularity.

As in the software arena, the CBPP characteristics of modularisation and granularity of work have emerged in the organisational basis of a modular development and production through small-sized modules. In the case studied here, these modules have been characterised in terms of geographically disseminated research institutions with an extended heterogeneous granular quality in respect of their location in different agro-ecological zones, which (largely) frames the (different) inputs of different (types) of actors and disciplines, and the combined software/hardware product development of varieties (Dedeurwaerdere 2012).

As in the software case, this heterogeneous granularity of agrarian production also makes it in principle impossible for any single module/contributor (individual or institute) to appropriate and claim ownership of the rice varieties produced. It is thus another important feature of the heterogeneous granularity of the agrarian production system is that *no single entity can hold an exclusive right to the end product*. The particular way in which the development and production of drought-tolerant rice varieties is socially organised – with heterogeneous (multi-disciplinary and agro-ecologically and work-site specific) settings and (individual and institutional) contributors – stimulates an approach of sharing and integrating all these different contributions towards a common goal.

Therefore, many scholars (Deibel 2013, Kloppenburg 2010a, Lemmens 2013, Kloppenburg 2014, 2010b) have insisted on this as a *practice of sharing* plant genetic resources, as opposed to the imposition of (strict) intellectual property rights. Indeed, the RRN is already built upon practices of sharing the breeding material without any legal obligations between the diverse set of institutions.[35] Thus, further to the dynamic developmental history and flexible and fluid (institutionally structured) organisational characteristics suggested above, various commons-based practices are evident in the RRN due to its specific social form, in which the production of drought-tolerant rice varieties is organised in heterogeneous modules (Hoffmann, Probst, and Christinck 2007).

However, the registration of the drought tolerant varieties at the NBPGR does mean that the varieties become 'public goods', which implies that they become managed and governed by state agencies and that bureaucratic measures to regulate the governing of these public goods may be formulated. It is possible for the NBPGR registration to become a first step in separating the varieties from the CBPP context in which they have

35 There is a complicating issue here of whether the sharing of resources and tools might serve to strengthen an exclusive use of the plant breeding framing of the drought problem and thereby reinstall new power relations around these institutions in the approach to specific problem solutions, or, on the contrary, whether this sharing may in fact tend to open perspectives for more egalitarian, democratic and diversified trajectories of knowledge production. This issue will be considered in another article.

been developed, and thus that this announces a future transfer of what are now public goods into the private domain. This uncertainty about what may happen in the future suggests that it becomes imperative to follow closely what actually transpires with the commonly developed drought tolerant rice varieties and thus also to reflect critically on the role of the affective, motivational labour within this production system of drought tolerant varieties.

In contrast to this, an alternative, more commons-based trajectory may elaborate further the social relations between farmers and scientists, through which the breeding lines are transformed into varieties attuned to the different farming practices in (specific to) the various regions. In this trajectory, the farmers and scientists decide together how the new drought-tolerant breeding lines can be best tailored to local conditions (Hoffmann, Probst, and Christinck 2007). Instead of transforming breeding lines into varieties through which farmers may become increasingly dependent on additional scientific information to practice their farming, the commons-based trajectory indicates the possibility of farmers working together with scientists to elaborate further their social relations and, through PVS, aim to transform the breeding lines in ways that are suited to their location-specific farming practices for dealing with drought (Ruivenkamp 2008, 2005).

Third, the discussion on CBPP always revolves centrally around building a network (Benkler 2006). This case of rice research network elaborated here has also been an evolving network since its inception. But the construction of rice research network is in many ways different than the relatively homogeneous ICT mediated information production networks. This network has been evolving over a considerable period of time in which it has gone through several metamorphoses, and it is constituted around several layers. It is also clear from the findings that like most of the peer production networks, members participate willingly in the knowledge production, and not by other obligation.

Thus, the scientists in the RRN give their labour not for personal material benefits but rather for a range of extrinsic and intrinsic, including inherently 'moral', non-monetary compensations. This also implies that the research products developed within this network are not claimed by individual scientists. In fact, the sheer number of scientists involved means that although the quantity of research inputs per se is not a motivation in this agrarian case, as it is in the computer research model, there actually are very many relatively independent contributors to the multiple rice breeding research programmes undertaken by the network, so the commoning effect on knowledge products of sheer quantity of inputs observed by Benkler does also pertain here. Given this, together with the modularisation of work and the diversity of institutional and disciplinary contributions to the development of drought-tolerant rice varieties, it becomes impossible to develop proprietary claims by one or some of the many participants, and any enclosure of the varieties by an individual or institution may be challenged by the many others.

The working culture within the network resembles other commons based networks (Benkler 2006). It is friendly, democratic, based on debate and discussion without any domination based on hierarchy, imposing authoritarian culture that often characterise the institutions from where the scientists are coming from. This culture is also extended to the farming communities too who are participating in the knowledge production process. Moreover, while the modularisation and heterogeneous granularity of the research work has individual researchers collaborating with the multidisciplinary network by elaborating a specific disciplinary issue, for the scientific elaboration of that issue, he/she works on and/or makes use of research experiences in other projects in which he/she is involved. In other words project borders become blurred, which makes it almost impossible to identify precisely what knowledge is produced where and by whom.

A striking feature of the RRN revealed by this research is the ambivalent presence in the Indian research institutions of a strong bureaucracy and top-down decision-making structure that nevertheless allows researchers to spend a part of their institutional research time on the development of drought-tolerant rice varieties for another organisation – *and*, moreover, the additional research activities are carried out in a loosely structured and apparently egalitarian organisation based upon cooperation, sharing and non-material rewards. The dual presence, therefore, of a *compulsive labour situation* (within the institutional setting) and an apparently *egalitarian freed work situation* (in the rice research network) poses the question of how the affective, motivational labour should be perceived.

Fourth, an important feature of CBPP is that it facilitates sharing of resources both material and immaterial within its members without much proprietary obligations. Commons based approaches thrives on sharing rather than confining it to a selective few (Benkler 2002, 2006, Benkler and Nissenbaum 2006). This is the reason many scholars have insisted on sharing of plant genetic resources rather than imposing strict intellectual property rights in agriculture that could lead to deter innovation. As a matter of fact the diversity of plant genetic resources we enjoy today was a result of thousands of year's free flow and sharing of these resources. We have observed in the case of rice research network that it allows sharing of breeding material without any legal obligations (such as even without MTA) between diverse set of institutions (such as ICAR institute, agri-universities, NGOs, international institutes).

Finally, it is often argued that CBPP mode is often seen as emancipatory and egalitarian in nature in which unequal power relations are negated in the process. However, as it is clear from the discussion above and below that GCP-RRN showed many features of

CBPP, but within these ostensible characteristics of CBPP in this network, there are also certain underlying structural power relations that too shape the functioning and construction of this network. For example, large chunk of the funding is kept for CG institutions – in this case for IRRI; advance technology oriented upstream research is done again in selective institutions; the number of plant breeders are more in number and the research direction of the network is often taken from the breeding perspectives; and finally sustaining within the network is meritocratic. These underlying structural power relations that shape its outcome are something which requires further exploration in other CBPP in information production domains.

This unequal structural power relation also manifest differently in the use of the end product of this network. Farmers while cultivating these varieties in their fields follow their own set of practices which sometimes differ with the prescribed form as suggested by the scientific communities. On the other hand, in academic setting (such as in the research papers) the ideas of the scientific community mostly prevails. In other words, further research is needed to find out whether and which new power relations are created at the upstream level of agrarian production around the use of specific biotechnological tools and resources. This, in turn, implies consideration of whether and how such relations are combined with the common usage (access to and sharing) of these items in developing breeding lines. In this sense, we may wonder, for example, whether the larger financial support for the international organisations than Indian research institutions illustrates this as a process through which unequal social relations are reproduced (at the institutional level) (McAfee 2003, Akram-Lodhi 2008).

Chapter 5

Understanding the development of drought tolerant variety Sahbhagi Dhan: towards a commons perspective

ABSTRACT

The concept of commons is often understood to refer to resources shared among a group of people. The resources are typically classified by binaries such as (non-)natural, (non-)rival and (non-) subtractable, and the analytical focus is placed on governance for sustainable management. Another approach to the idea of commons emphasises social relations. This concentrates on production resulting from human-human and human-nature interactions. Here, we focus on the latter and investigate the relationship between these two conceptualisations. This is enabled through an empirical study of the development process of a drought-tolerant rice variety, Sahbhagi Dhan, which was the result of a twelve-year long collaboration between the International Rice Research Institute (IRRI) and other different Indian institutions. We argue that the concept of the common as a production system can be characterised as an interwoven process of community building involved in the production of resource commons, and we indicate several features of the community-building process that are essential to an understanding of commons as a socially specified system of production.

Keywords: Commons; Governance; Community Building; Sahbhagi Dhan; India

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5.1 INTRODUCTION

Since the publication of '*tragedy of the commons*' (Hardin 1968), the literature on *commons* as understood as shared natural resources among a group of people, has been growing. The central focus of such analysis tends to revolve around the governance mechanisms of such shared resources in which individuals and/or communities devise ways through the combination of informal norms, trust, and a small set of formal rules to manage shared resources for individual and collective benefits that often works better than the government imposed formal mechanisms (Agrawal 2014, Anderies and Janssen 2012, Berge and van Laerhoven 2011). This type of analysis is further extended to study the governance of knowledge resources that is complex, multi-layered, non-subtractable and non-rival in nature (Hess and Ostrom 2007b). The central focus of analysing knowledge *commons* revolves around the sharing mechanisms of ICT mediated digital forms of knowledge to thwart the pervasive IPR regime that has created another tragedy namely *tragedy of the anti-commons* (Heller and Eisenberg 1998). However, there is another way of understanding *commons* in which commons refers to the outcome of social production over a considerable period of time due to human-human or human-nature interaction such as language, knowledge, plant genetic resources etc. (Hardt and Negri 2009). This aspect of *commons* as a production system that refers to the production of *commons* is largely neglected in the dominant discourse on *commons*. This paper aims at reflecting on this neglected domain.

This is important particularly for two reasons: first, this will take the debate around *commons* from the governance or management of shared resources towards the production of *commons* in which social relations are reconfigured, indicating that a production system is emerging that is distinct from state based or market based production systems; second, as we are moving towards knowledge society or knowledge economy, our society has been invaded with products that often have a knowledge component along with a physical component, therefore, the production of such products indicate how knowledge component and natural resource component are often intertwined in creating a hybrid *commons*. This paper focus on such a hybrid *commons* investigating empirically the development of a drought tolerant variety namely Sahbhagi Dhan that combines both the physical-tangible component (the agricultural crop) and informational-intangible component such as the genetic trait of drought tolerance that is often inserted through advanced biotechnological tools (such as molecular markers and the knowledge which is required to cultivate it). The name Sahbhagi – that means "something which is developed out of collaboration and cooperation" in Hindi language – itself symbolically relates to the debate on *Commons*. This variety was developed by joint research collaboration between the International Rice Research Institute (IRRI) and other different Indian institutions over a period of 12 years between 1997 and 2009. This research collaboration between IRRI and other Indian partners here is referred as Rice Research Network (RRN). Sahbhagi Dhan has been released for commercial cultivation in the drought-affected areas of Jharkhand and Odisha (India) in 2009. The same cultivar has also been released in Bangladesh (as BRRI Dhan 56) and in Nepal (as Sookha Dhan 3) (Dobermann 2012). Moreover, in another paper (Basu, Jongerden, and Ruivenkamp Forthcoming), it is shown that a *complex and extended CBPP mode* is emerging within the GCP drought-tolerant rice research, therefore, comparing to software arena where commons are created through the CBPP mode of production, it is important to investigate a product of this network can be considered as a common. To this end, the process of the development of Sahbhagi Dhan (as a product of this GCP drought-tolerant rice research) is analysed to see the extent to which this variety can be termed a common. The main research question of this paper is: how and to what extent can the drought-tolerant rice variety Sahbhagi Dhan, developed within GCP drought-tolerant rice research, be regarded a common?

This paper applies a critical constructive approach in which the dominant discourse on *commons* is critically reviewed, and further based on the empirical analysis on the development process of Sahbhagi Dhan; a constructive framework on commons is developed in which some key aspects on *commons* as production system is suggested. The constructive part on *commons* as production system is analysed as an interwoven process of community building that is involved in the production of *commons*. This paper is organised as follows. After this short introduction, the theoretical framework on commons is elaborated that is followed by the methodology employed for this research. Then, the historical process of Sahbhagi Dhan development is described that is followed by the discussion and conclusion.

5.2 THEORETICAL FRAMEWORK ON COMMONS

In the literature, we find two different ways to understand *commons*: *commons* as a resource that is shared by a group of people, participating in making decisions about how those resources should be used (Dietz, Ostrom, and Stern 2003, Ostrom 1990, Ostrom et al. 1999) and commons as an outcome of social production over a considerable period of time due to human-human and/or human-nature interaction resulting into language, knowledge, plant genetic resources, biodiversity and so on and so forth. Sometime the former is referred as '*natural commons*' and the latter is referred as '*artificial commons*' or '*constructed commons*'. However, such division within commons is not of primary as both types of *commons* are subjected to different ways of enclosure. Neoliberalism is aiming at privatizing both types of *commons* (Hardt and Negri 2009, Hardt 2010).

Reference of commons as a natural resource has its roots in the European intellectual history, where it referred to shared agricultural fields, grazing lands, and forests that were, over a period of 500 years, enclosed by land owners and the state withdrawing the communal rights. According to European political text, *commons* refer to the material wealth of the world such as the air, the water, the soil, the seed, and all nature's bounty, which is claimed to be the inheritance of humanity as a whole, to be shared together. The Romans has two categories of laws: one, *res publica* that means inherently public property to be managed by the government; and *res commune* that means things common to all to be used and enjoyed by everyone (Bollier 2002, Hardt and Negri 2009).

5.2.1 Management of commons

Referring to this "common use of things" a voluminous literature emerges refuting and rebutting particularly the deterministic claims of Garrett Hardin that he made in the article titled *tragedy of the commons* in Science in 1968. In that article, while describing an unregulated and open access pasture, Hardin made two claims: 1. Resource users are stuck in an inexorable *tragedy of overuse* of resources, and 2. Sustainable resource use requires either state or private property management (Dietz, Ostrom, and Stern 2003). Through several case studies on management of fisheries, forests, and grazing lands or pastures, Elinor Ostrom together with her colleagues refuted this conventional wisdom of Hardin stressing that the tragedy of the commons is not obvious and therefore, cannot be generalised (Ostrom 1990, Ostrom et al. 1999). Ostrom showed through innumerable case studies that individuals do devise collective ways to manage sustainably common pool resources for individual and collective benefits. This *self-organized management of resources* works better than any externally imposed rules onto them. Ostrom through her several case studies showed the evolution of institutions for collective action, and further extrapolated that to explain the design principles of long lived commons. Ostrom identified *trust, reciprocity, and communication* as three key building blocks for collective action (Araral 2014).

However, the case studies that Ostrom cited involved few hundred or so actors, and anything much larger, she argued, would *require a nested structure of decision making* because direct negotiation between all individual would be impossible. Elinor Ostrom (who later won Nobel Prize in institutional economics), Bloomington School of institutional analysis, and the International Association for Studying of the Commons (IASC) till date remained the most dominant school of thought in studying the commons. It is also a matter of fact that this school of thought is much relevant for small scale locally governed commons, while its relevance in studying large scale national regional and global commons remained contested (Basu 2014, Harvey 2012).

Along with her colleague Charlotte Hess, she extended the commons debate to knowledge. Together they edited a book titled 'understanding knowledge as commons: from theory to practise' in 2007, in which they argued knowledge as a complex, multi-layered, non-subtractable and non-rival shared resource that is subjected to social dilemmas. In this book, knowledge is conceptualised as a shared resource, a complex ecosystem that is a commons – a resource shared by a group of people that is subjected to social dilemmas. The focus here is on the availability of digital form of knowledge, and thus possibilities to share and /or access knowledge through digital form as well as keeping it as commons. The connection between knowledge and commons is made through identifying typical problems associated with natural resources commons such as congestion, overharvesting, pollution and inequities that are also common to knowledge resources. Further, effective alternative to solve these problems such as social rules, appropriate property rights, and management structures are proposed for knowledge resources in line with the natural resources commons. After justifying commons metaphor to knowledge, this book proceeds with discussing problems that knowledge commons might face, such as free-riding or disappearing assets, creating depositories of knowledge through voluntary contribution by the scholars, and finally, focuses on protecting knowledge commons through unprecedented access to information through internet from commodification and enclosure (in the form of intellectual property legislation, patenting, licensing and overpricing) (Bollier 2007, Hess and Ostrom 2007b, Kranich 2007, Crispin 2008).

At this point it is important to note the very nature of knowledge and its non-rival and non-subtractable criteria – then it can be said that unlike natural resources commons that are both rival and subtractable and characterised by scarcity – knowledge commons on the contrary is characterised by its abundance. This abundance of knowledge commons has been celebrated within the alternative models of knowledge production such as CBPP that is embodied through the free software movement. This model showed the power of networked, open collaboration, and non-material incentives to produce better quality products (mainly software).

However, the issue of knowledge commons also becomes apparent with the change towards a knowledge intensive society and with the change in the science institution to produce knowledge in a profit oriented way similar to the very practices how global corporations creates technology. This practices are not only limited to the science institutions but the traditional knowledge that is usually held by a community is also privatised and patented by different companies. Excessive protection and patenting of technology and knowledge have also created impediments for innovation, which is also called as tragedy of anti-commons (Heller and Eisenberg 1998).

We find the dominant school of thoughts on commons problematic on the following counts: 1. knowledge commons and natural commons are treated separately which is problematic especially when it comes to products that are combination of both natural resources and knowledge resources, for example, in this paper we are dealing with drought tolerant plant variety (namely Sahbhagi Dhan) that is a combination of both natural resource (i.e. plant variety itself) and drought tolerant trait that is inscribed into it (knowledge or informational component); 2. commons are placed in-between state and market (Caffentzis 2008) and a case is made for a continuous struggle to get the commons recognised by the state (Hess 2008), whereas, in the later part of this paper we will show that the commons cannot be demarcated by the state, hence, goes beyond the binary of state and the market; 3. the issue on knowledge commons are often linked with the techno-scientific academic knowledge (Hess and Ostrom 2007b) as we will show in the case of Sahbhagi Dhan that both scientific and indigenous knowledge (farmer's knowledge) coexist in creating a commons based knowledge system (at least in this case), therefore, the issue of indigenous knowledge is equally important along with the scientific knowledge; and finally, 4. the dominant school of thought on commons starts from the 'tragedy of commons' in the case of natural resource commons (Hardin 1968) to another 'tragedy of anti-commons' in the case of knowledge commons (Heller and Eisenberg 1998). In this paper, as it will be illustrated that we are not interested in 'tragedies' but in perspectives on commons that may well go beyond the management or governance of commons, particularly in the context of knowledge intensive products such as a plant variety that contains both knowledge commons as well as natural resource commons. Therefore, in the following paragraph, we elaborate the second strand on *commons* that particularly refers to production process of commons or commons based production systems.

5.2.2 Production of commons

Within the reference of commons as a production process, it is seen as an outcome of social production over a considerable period of time due to human-human or human-nature interaction such as language, knowledge, plant genetic resources, biodiversity and so on and so forth. Therefore, the production process and "the common products" are inseparable from each other. Historically, the mankind always organised valuable resources through collective action such as the plant genetic resources (PGR). Many argued that the default mode of economic organisation is commons based (Bollier 2002, Ruivenkamp 2015b). In United States, commons has most often referred to shared spaces that allow for free speeches and the democratic process. This is the focus of Benkler' s (2004) 'commons based peer production'. This is the story of digital interoperability, open science, collaborations and scholarly networks, voluntary associations, and collective actions. The US type commons underscores the importance of shared spaces and shared knowledge in fostering viable democratic societies. There are many different ways through which commons evolve or come into being. Yet, they all had a sense of "sharing" and joint ownership (Hess and Ostrom 2007b). According to Caffentzis (2008:5), commons operate in the conceptual *terra nullius* between market and government, therefore, it is neither under the control of government nor under market regulations. Thus, it offers a possibility to transcend beyond the simplified dichotomy of exclusive private vs exclusive public (Halewood 2010).

It is difficult to conceive of commons without a particular community. Hollenbach (2002) states that commons is realised in the mutual relationship through a community. However, it is not merely the outcome of a collective action, but the important issue is that of "a shared enterprise". Therefore, we can say that commons and community come into being through that enterprise. Commons can be found in the actions that generate it, and thus benefitting from the *commons* is through participating in that action process. The existence of *commons* is mainly due to shared action that makes it possible in which people participate freely because of many reasons thereby developing and sustaining it (Deneulin and Townsend 2007). Indigenous knowledge and biological resources are also held and nurtured by different communities/collective enterprises. Therefore, 'no commons without community' is an accepted axiom in commons study (Caffentzis 2008). In order to study any *commons* initiative would then be to analyse how inclusive communities with equal access, benefits and control are built that can defend the *commons*. This entails building inclusive and representative institutions of production, governance and distribution in a manner that encourages and embraces diversity, difference and dissent (Cheria and Edwin 2011a). In this paper, we would like to explore the development process of Sahbhagi Dhan (an example of both natural and knowledge commons) through an interwoven process of commons and community building to indicate some of the key aspects of commons based production, and through that this paper also aims at addressing some of the above mentioned criticisms of Ostrom school of thought.

5.3 METHODOLOGY

On the more theoretical level, this research applies a critical-constructive approach to first critically evaluate the *commons* literature as a way to study governance structure of a shared resource. Furthermore, a constructive approach has been applied to make some suggestion to conceptualise it as a way to understand the production of commons. This constructivist part in re-thinking the *commons* as a production system is substantiated empirically with the development of the drought tolerant rice variety the Sahbhagi Dhan. The empirical part of this research is built upon a historical-timeline analysis of the development and dissemination of Sahbhagi Dhan through which the constructive part of *commons* scholarship is reflected upon.

Sahbhagi Dhan variety was developed within joint research collaboration between several national and international research institutes, universities, transfer of technology centres, NGOs, state agencies, and farmers' organizations. These institutions are: Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur, Central Rainfed Upland Rice Research Station (CRURRS), Hazaribagh, Narendra Dev University of Agriculture and Technology (NDUAT), Faizabad, Birsa Agricultural University (BAU), Ranchi, Central Rice Research Institute (CRRI), Cuttack, Tamil Nadu Agricultural University (TNAU), Coimbatore, Barwale Foundation (BF), Hyderabad, University of Agricultural Sciences (UAS), Bangalore, Anand Agricultural University (AAU), Anand, Orissa University of Agriculture& Technology (OUAT), Semiliguda, Maharana Pratap University of Agriculture and Technology (MPUAT) Banswara, Vivekananda Parvatiya Krishi Anusandhan Sansthan (VPKAS), Almora, and Jawaharlal Nehru Krishi Vishwavidyalaya (JNKVV), Rewa, and in the Philippines, IRRI (Los Banos) (CGIAR Generation Challenge Programme 2011). Moreover, several farmers groups were also involved within the development of Sahbhagi Dhan particularly during the Participatory Varietal Selection (PVS).

Secondary data on the historical development and dissemination came from a careful literature review from several documentary sources such as research papers, scientific blogs, news-letters, annual reports, technical bulletin etc. After this, the first author undertook a fieldwork for 3-4 months (April-July 2012) to collect primary data from the particular scientists who were associated with the development of this variety in several locations in India and in the Philippians. Scientists were thoroughly interviewed on their involvement with the RRN projects, history of the development of Sahbhagi Dhan, details of the organisational structure of RRN, the relation between ICAR/ CGAIR with the RRN, and finally the role of farmers into this variety development. There were several rounds of interviews made with the head of these organisations to get their view on this project. A total 45 in-depth interviews were done with the scientists, directors and others.

Further, farmers group that are associated with the institute CRURRS at Hazaribagh had played a crucial role in the development of Sahbhagi Dhan. Therefore, this group of farmers were interviewed during another visit between October-December 2012. Around 100 farmers including women farmers were informally interacted. Several focused group discussions (FDGs) were also held with them. Further, 45 farmers, who were closely worked with the development of Sahbhagi Dhan, were interviewed in-depth. These in-depth interviews, informal talks, and FDGs constituted the primary data. This research is mainly a qualitative one as we are trying to understand the process of the development of a plant variety from a particular theoretical perspective.

Theoretical insight that has guided the data collection as well as the data analysis is taken from understanding the commons as production system or production of commons as elaborated in 5.2.2. Production of commons can be understood from the production process of the commons (in this case Sahbhagi Dhan) that is historically analysed. The historical timeline is constructed by narratives from those actors who were involved concurrently cross checking the data from available literature sources. The central theme of the analysis, following commons literature, was to see the production of commons as an interwoven process of community building. In other words, the analysis is made on how through the development process of Sahbhagi Dhan, a community is created. Further, some of the features of this community are identified in-tune with the broader literature on commons as features belonging to commons based production system.

5.4 THE HISTORICAL ANALYSIS OF THE DEVELOPMENT AND DISSEMINATION OF SAHBHAGI DHAN

Sahbhagi Dhan is a drought tolerant rice variety that was developed from the breeding line IR74371-70-1-1-CRR-1 through a joint collaboration between the IRRI and other Indian agricultural institutions that are listed in the previous section over a period of 15 years. This line was released and notified in October 2010 with the name Sahbhagi Dhan (SD) by the Central Rainfed Upland Rice Research Station, Hazaribagh. Because this variety has been developed through collaboration between several institutions (national as well as international), it has been named as Sahbhagi, which means collaboration in Hindi language. This variety was released for cultivation under direct seeded upland conditions for the states of Odisha, Jharkhand, and Chhattisgarh and transplanted lowland conditions in the state of Tamil Nadu. Jharkhand and Orissa are the two most drought affected states in the eastern Indian rainfed region with mild to moderate drought at one or more stages of the rice crop every year, and severe drought occurring every 4–5 years (Mandal et al. 2009).

This variety has been developed by using conventional breeding strategy. Its performance under both drought and favourable conditions is consistently good. Under normal conditions, Sahbhagi Dhan produces 4-5 tonnes per hectare whereas other varieties yield about 2.5 tonnes per hectare. Under severe drought conditions, this variety produces 1-2 tonnes per hectare, while other high yielding varieties produces nothing under drought conditions. With respect to irrigation, Sahbhagi Dhan requires two irrigation compared to four irrigation that is required by other traditional varieties such as Sarju 55 and Sambha Mahsuri. Less number of irrigation allows farmers to save up to $60 per crop. Sahbhagi Dhan is an early maturing variety that matures in 105 days than other medium and long-duration varieties that usually take 120-150 days to mature. This allows farmers to plant the next crop (usually Rabi crop such as wheat) earlier which in turn give them enough time to plant three crops in a year. Moreover, Sahbhagi Dhan produces better straw yield and the quality of straw is also better than other varieties. Even, it is reported that buffaloes liked the Sahbhagi Dhan straw more than other straw. Many have attributed this to the straw quality which is softer than other straws (Mandal et al. 2009).

The development of Sahbhagi Dhan was started in 1997 by a French rice breeder named Bigitte Courtois at IRRI under the programme Upland Rice Research Consortium (URRC). URRC was in existence between 1991 and 1999, and was headed by IRRI along with its NARS partners in Indonesia, Philippines, Thailand and India. Bigitte Courtois had made a cross between two South East Asian rice varieties: IR5541-04 (South East Asian Indica) and WayRarem (Tropical Japonica), of which IR5541-04 was the donor for drought tolerance. Based on pedigree selection Dr. Courtois selected a new line IR74371-70-1 for upland rice. Dr. Courtois was conducting her research in an upland rice site in Siniloan in the Philippines near IRRI's headquarters in Los Banos (Dobermann 2012). After nearly a year, Dr. Gary Atlin joined IRRI as a rice breeder started testing this breeding line for drought tolerance under (i) Eastern India Farmers Participatory Breeding Project (EIFPBP) that was funded by the International Development Research Council (IDRC) 1997-1999, and (ii) the Consortium the Unfavourable Rice Ecosystems (CURE).[36]

The CURE programme was initiated to study challenging upland and lowland rice conditions. The programme was focussed on three contemporary rice problems: drought, submergence and salinity. The CURE programme was headed by IRRI and had its Indian partners in Hazaribagh, Raipur, Faizabad, Bangalore, Coimbatore and Cuttack. Initially, when testing this breeding line through CURE programme Dr. Atlin thought that probably this new plant type could be called as Aerobic rice that would be a moderately drought tolerant, input-responsive kind of upland rice that could work well in upper locations of more favourable rain fed environments. In this time, around 2003, Dr. Atlin proposed to form a network as upland rice shuttle breeding network (URSBN) along with IRRI and other CURE programme partners. The URSBN was initially funded by the core funding of IRRI. Within the CURE programme as well as the newly built URSBN this new breeding line was tested between 2003 and 2005. In 2005 another similar network named as Drought Breeding Network (DBN) was initiated to study drought conditions in lowland areas. This network received funding from the Rockefeller Foundation (RF) and the Generation Challenge Programme (GCP) under a project titled 'Developing and disseminating resilient and productive rice varieties for drought prone environments in India' (2005-2008).[37]

RF's association with developing drought tolerant rice variety goes back to early 1990s. In fact RF started the initiative of drought research in India when neither the importance of drought was felt within ICAR nor the ICAR had the capacity to deal the drought problem. RF has trained many Indian scientists with advanced biotechnological applications in the United States who are mostly involved today within this rice research network (URSBN and DBN). Under RF's initiative International Rice Biotechnology Network (IRBN) and the Asian Rice Biotechnology Network (ARBN) were formed. On the other hand, GCP was created in 2003 by the CGIAR to improve crop varieties

36 Interview, Interviewee 1, Hazaribagh, IN, 2-4 June, 2012.

37 Interviews: Interviewee 1, Hazaribagh, IN, 2-4 June 2012; Interviewee 2, Hazaribagh, IN, 2-4 June 2012.

for drought tolerance around the world. Both GCP and RF had at that time common interest on developing drought tolerant rice varieties which were channelized within this rice research network.[38]

Upon consistent and promising performance during the initial trials, in 2005 this breeding line was nominated for testing under the All India Coordinated Rice Improvement Programme (AICRIP) by CRURRS. During several AICRIP trials between 2005 and 2007, this breeding line showed a yield advantage of 29.2% and 19.1% over the national and regional check varieties respectively under rain fed drought affected situations. It also showed a yield advantage of 22.8% and 31.4% over national and regional check varieties under non-stressed conditions. Under drought conditions, it showed a significantly higher yield than all the checks in Bhubaneswar, Cuttack and Rewa. At the same time, during the same period, this breeding line was also tested within the DBN on-station breeding trials which were conducted in eight locations for three years (2005-2007). In these DBN on-station breeding trials, the line had an average yield advantage of 0.5 t/ha under moderate drought and 1.0 t/ha under severe drought conditions over IR64 and IR 36, the two prominent varieties grown in these regions. Under irrigated control situations, this variety had a yield advantage of 0.1 and 0.8 t/ha over IR64 and IR36 respectively. The breeding line was recommended for release in the AICRIP annual meeting in 2008 and was subsequently released for cultivation in 2009 (Mandal et al. 2009).

Therefore, as we see that the RRN which is consists of mainly two networks today: DBN and URSBN, has been evolved around several projects such as CURE, URRC etc. that were funded by different international organizations such as RF, GCP, IFAD, IDRC, BMGF etc. As it is evident from the historical description provided above that the development and dissemination of Sahbhagi Dhan remained a central part of the development of RRN. Scientists who are involved within this research community are mostly employed by the ICAR research institutes, State Agricultural Universities (SAUs), and Transfer of Technology (TOT) centres. Other professionals come from NGOs and of course from the CG centres. Salary of the scientists, research facility, and other recurring costs are taken care of by the respective institutions from which scientists have joined the RRN. Scientists willingly participate in this research community without any obligation from their institution to do research. They participate for a number of reasons. Some of them participate to receive good quality breeding material from IRRI as they consider Indian breeding material somewhat inferior when compared with the breeding material from IRRI. Some of them participate because of the fact that doing research within this community brings international exposure; recognition within the scientific community as well as it offers possibilities for good peer reviewed publications, which would be difficult if they are working alone. Some scientists participate because it offers

38 Interview, Interviewee 3, Bengaluru, IN, 19-23 June, 2012.

them a possibility to develop the research infrastructure of their home institute. For example, through the GCP projects, CRURRS has got a rainout screening facility (cost $2000) and a root scanner that is helpful in conducting drought research. And finally, many scientists work in this community as it is another way for them to contribute to agricultural sciences and to help farmers.[39]

In participatory varietal selection (PVS) trials, this breeding line was preferred by farmers under both irrigated control and drought situations. IR74371-70-1-1 has also shown promise in Nepal and Bangladesh in 2009 drought-screening experiments and PVS trials with farmers. In 2009, in farmers' PVS trials, the seed of this variety was distributed to a few farmers in Jharkhand. In Singrawan Village of Hazaribag District, eight farmers were each provided with 5 kg of seed for planting under farmer-managed trials along with current varieties. Because there was no rain for the first 45 days of the season, farmers were not even able to plant in their nurseries. In frustration, four farmers broadcast the seeds of Sahbhagi Dhan on their fields with very little hope of getting any harvest. Fortunately, a few days after sowing, scanty rain helped this variety to germinate. Eventually, the farmers were able to reap a harvest of 1.8 t/ha from these fields, whereas, in the adjoining area of around 12 ha, no crop could be planted and the land remained fallow (Mandal et al. 2009). Scientists expressed unanimously that they enjoy very much working with the farmers during the PVS session. They are quite open in taking the feedbacks from the farmers and they learn a great deal (see for example next section) from the farmers. It was also clear during the FDGs with the farmers that they have high regards for the scientists and they share a very cordial working relation with them. It also came out from the FDGs that the scientists never behave in an autocratic and imposing way. Farmers often disagreed with the scientists and often modify the prescribed practices according to their convenience and conventional wisdom. For example, one farmer said:

'Scientists asked to sow the seeds of a particular drought tolerant variety while the field is dry. However, because of the untimely rain, farmers went on to sow the seeds while the field was muddy. It was difficult to postpone the sowing or wait until the field is dry because of the delay in crop cycle. Sowing during the muddy field yielded better crop than sowing in dry field.' – Farmer Respondent on 14th December 2012, Hazaribag District.

It was clear that both scientists and farmers learn from each other greatly. Therefore, this RRN is very inclusive and extended the democratic culture to the farming communities too.

Looking at the research activities of the development of Sahbhagi Dhan, we observe a

39 Interviews: Interviewee 3, Bengaluru, IN, 19-23 June, 2012; Interviewee 5, Raipur, IN, 12-13 July, 2012; Interviewee 6, Ranchi, IN, 6-8 June, 2012; Interviewee 7, Cuttack, IN, 15-18 June, 2012; Interviewee 9, Los Banos, Philippines 2-4 May, 2012.

range of disciplinary activities. These included field screening (phenotyping), genotyping (often with advanced level molecular and biotechnological tools), screening (for disease and pest resistance), associated breeding activities and, of course, conducting the PVS. In order to perform all these activities, the network comprises of a high number of breeders comprising professionals across several disciplines. These fall into such categories as plant breeding, genetics, physiology, pathology, entomology, biostatistics and social sciences. Each step of disciplinary input into the breeding activities is essential for the next, so each discipline actually works in a way that is intertwined with others to produce knowledge related to drought resistance.

An intensive seed production program has been used to disseminate this variety in drought-prone regions of eastern India in collaboration with CRURRS-CRRI; Birsa Agricultural University (BAU), Ranchi; Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur; state seed corporations; the National Seeds Corporation, Ltd. (NSC); and various NGOs. The variety was recognized in a meeting of the Central Varietal Release Committee held on 24 October 2009 and approximately 2.5 tons of breeder seed are expected to be available by the end of the 2009 wet season. Many agencies are producing the seed again during boro (dry) seasons and increasing the quantity to more than 100 tons before the wet season of 2010. The National Food Security Mission has chosen Sahbhagi Dhan, along with submergence-tolerant variety Swarna-Sub1, for a large-scale promotion during kharif 2010 through their minikits program. They are planning to promote it in drought-prone areas in Jharkhand, Bihar, Chhattisgarh, Uttar Pradesh, and Orissa (Mandal et al. 2009).

The members of RRN usually meet once in a year at any partner institution for the annual review and planning meeting. In this meeting, previous work is evaluated and planning for the coming period is done. Individual scientists present their work and further they themselves decide for the future work that they are going to undertake. Research assignments are distributed based on mutual assessment of how much work respective scientists are willing to do. Generally, the work culture of the RRN is friendly and democratic that is based on debate, discussion and consensus building. Each scientist has equal stake in the RRN and well heard of. Scientists are fairly autonomous in deciding how they are going to conduct their research and there is no imposition from the RRN. Proper recognition is given to scientists and they work together in a spirit of cooperation and collaboration for a common goal. The scientists communicated among one another regularly through Skype, email and personal visits. Although loose set of leadership from the IRRI is present, however, this leadership is not based on centralised moderation. Maintaining a position within this community, however, occurs purely on a merit basis.[40]

40 Interviews: Interviewee 1, Hazaribagh, IN, 2-4 June, 2012; Interviewee 2, Hazaribagh, IN, 2-4 June, 2012; Interviewee 6, Ranchi, IN, 6-8 June, 2012; Interviewee 7, Cuttack, IN, 15-18 June, 2012;

Therefore, this RRN is situated within several institutions such as government institutions, international institutions, NGOs, and farmer's organizations. People who are either employed by those institutes or work for them come together and work within this RRN. This RRN exist because of common interest of these people to contribute towards drought research. This RRN is not moderated or controlled by any partner institute through their structural rules and regulations. In a sense, this RRN is not a legal entity recognised by the state instruments. This network is largely independent or autonomous in deciding its research agenda. Regulatory decision making organisations such as the ICAR or CGIAR can't impose its research policy to this network. This network frame its own research agenda based on discussing it with its own members. This network exists at the confluence of several institutions, yet it is distinct from those institutions. There is certain vagueness about its existence as it is difficult to locate through existing state mechanisms. However, ICAR or for that matter CGIAR regularly evaluates the outcome of the projects that this network undertakes. This network evolved as a supra hybridized entity and situated within a pseudo institutional sphere. This existence of this network at the pseudo institutional sphere gives it certain flexibility to conduct research that often complements the overall research programme of ICAR or CGIAR, yet at times, this network was able to frame research that is much more advanced than the existing ICAR research.

5.5 DISCUSSIONS AND CONCLUSIONS

The aim of this paper was to understand the concept of *commons* as a production system (or production of commons and/or commoning process) instead of *commons* as a governance mechanism/arrangement of shared resources (often natural resources as well as knowledge resources) which is still the dominant discourse on *commons* (Araral 2014). To understand the concept of *commons* as a production system, theoretically, we relied upon analytically to the notion of *community building process* as interwoven with the production of *commons* (Berkes et al. 1989, Mies 2014). In this concluding section, we will provide some of the key features of this *community building process* and production of commons that is built upon the empirical case of the development process of the drought tolerant rice variety Sahbhagi Dhan. We also aim at answering the research question that guided the entire study: to what extent the variety Sahbhagi Dhan can be called as *commons;* simultaneously, addressing some of the criticism of understanding *commons* as a governance mechanism as highlighted in the section 5.2.1.

In Indian context, prior to the release of the variety Sahbhagi Dhan, most of the mega varieties or widely cultivated varieties (such as IR varieties or Bt-cotton) were developed either through state monitored (ICAR) trajectories or market based trajectories (such as

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Interviewee 8, Cuttack, IN, 16-18 June, 2012; Interviewee 5, Raipur, IN, 12-13 July, 2012.

Bt cotton). As it is evident from the previous section the Sahbhagi Dhan didn't follow either of these trajectories. In certain sense, the development process of this variety started as *an experimental and unplanned way in which previous research has been taken up for further experiments and improvements*. However, over a period of time, a research community has been built concurrently with the development process of this variety. This institutionalized community was also not built by any single institution rather it was part of a network that has been evolving over last 20 years, and in that sense is still under permanent construction, as after the termination of GCP research projects, the community is sustaining itself through the STRASA programme and continuing its research for drought tolerance (Ruiz-Ballesteros and Gálvez-García 2014). Earlier studies although stressed that discussion on commons is incomplete without community, however, without explaining its various internal relations. Here, we would like to conclude that development of a community building process based on shared practices in relation to create resource or managing resources is tentatively the first aspect to look for understanding commons based production (Ruiz-Ballesteros and Gual 2012). In this case, the community and resource has been co-evolving concurrently. The very fact that the community is evolving with the resource creation itself denotes a degree of commons based production system.

However, the experimental and unplanned research community evolved as a dynamic one and has been built in several layers, such as different projects, different funding agencies, and different institutional set-up. Through this layering, this community tries to create institutional space within the institutionalized research community so that it can maintain its autonomy towards maintaining its research and development trajectory. The autonomy of the community has also been reflected within the internal dynamics of this community which is non-hierarchical, horizontal, and inclusive in nature. The work culture of this research community is based on discussion, debate, and consensus building regarding the research planning and approach. In certain sense, the research activities of this community are developed within a bottom-up flow where individual actors have rigorously participated in developing the research community. Scientists who participate in this research community are doing that without any structural obligations from their respective institutions. This volunteerism and self-willing participation of scientists contributed towards maintaining individual as well as the collective autonomy of this research community. This non-hierarchical, horizontal, and inclusive culture of this community which is based on democratic discussion, debate and consensus building is a striking feature of this research community as scientists within this community come from institutions such as ICAR and CGIAR that are mostly organised around centralised decision making in a top-down manner (Hall et al. 2001). This inclusive nature of this research community has also been extended to the farming communities that are involved at a peripheral stage of knowledge production of this research community. It is an imperative for any commons based production to organise the internal dynamics in a non-hierarchical, horizontal and inclusive way (Harvey 2012) as has been the case for this particular research community.

This nebulous organizational form of the experimental and unplanned research network indicates that this research community can't be demarcated as a legal entity i.e. no particular institution is having the exclusive right claim its existence. Therefore, this nebulous nature of its existence at quasi-institutional level allow us to think beyond of something which is either public or private (Öztürk, Jongerden, and Hilton 2015). It is also a fact that commons can't be recognised by the instruments of state. The moment the state recognises *commons*, it becomes vulnerable for enclosure (Basu 2014). Understanding of the commons requires a different form of imagination that is beyond the notion of policy, property and law, which is mainly implemented or recognised by the state. There are lot of activities within the community in regard to knowledge production, but this community only exist within the fluid overlapping institutional sphere. No single institution exclusively can claim its existence. Therefore, we conclude that this fluid nature of this community at non-state and non-private sphere can't be recognised by the state as it doesn't exist as per state vocabulary. This type of existence is very important for any commons based production system.

Therefore, as the dominant school of thought on commons places commons between state and market, somewhere in-between, is not valid here as we see it is beyond state, market, public, private, public-private or something in-between. The fact that many commons scholar emphasize the need of getting the commons arrangement recognised by the state or indicate a continuous struggle to get it recognised (Hess 2008) itself is antithetical to the existence of commons. What happens when the state recognises commons? There is a high possibility that the commons then become common property, and from common property to public property to public private partnership (PPP), and finally private property. Commons are resources not commodities, possessed not property, managed not owned. If there is anything most inimical to the commons – it is the very existence of the state (Aier et al. 2011, Bandyopadhyay 2011, Cheria and Edwin 2011c).

For example, in many Indian villages, land is owned in commons and administered by local mutually understood laws. The ownership is vested by the ability to use the land and the land is often inherited. The ownership is not enacted by legality, and the users do not know which parts of the land belongs to them. No sooner the state recognises the ownership by attaching legality to it than it becomes vulnerable to enclosure as the land is then demarcated to individuals. Now individual can sell his/her portion of the land that will lead to the fragmentation or the entire land can be acquired for some other purposes using the legality attached to it, thus the possibility can be either the land is appropriated or privatised. Therefore, the state recognition through attaching legality adds vulnerability of enclosure to the commons. If the commons cannot be demarcated by legal measures, then fragmentation or privatisation possibility is less likely [Please see (Katju 2011) or Cheria and Edwin 2011, pp 11-12 for more details].

Finally, this research community has been built around plurality. There are mainly three types of plurality involved in the community building process: first, plurality in actors (both individual actors and institutional actors), second, plurality in disciplinary activities, and third, resources (in terms of funding) have been mobilised from plural sources. This community has been organised within several national and international research institutes, universities, NGOs and local farmer's organisation, and comprised of several individual actors who are scientists, professors, administrators, extension workers, and farmers. The research approach of this community is embedded within an interdisciplinary framework that comprises of several disciplines such as plant breeding, biotechnology, statistics, plant physiology, and social sciences. These disciplinary activities work in an intertwined and integrated manner to approach the drought problem. And, finally, the resource required for sustaining this community building process has been mobilised from diverse sources such as initially the funding was provided by the RF, then the GCP, and now it is getting funding from the BMGF. However, apart from this research funding, regular recurring costs such as the salary of the researchers and research infrastructure costs are borne by the respective institutes. Therefore, we conclude that this research community doesn't aim at imposing singularity rather it has been thrived in plurality where this community has successfully created platform/conditions for co-existence among diverse practices towards a common objective (Cheria and Edwin 2011b, De Angelis 2014, Öztürk, Jongerden, and Hilton 2015). The practices of plurality within commons based production or commons is very important as it negates the ownership debate in relation to the resource in hand. C*ommons* are always vulnerable to enclosure, but the more plurality is present in process of community building, the more possibilities to appropriate it by a single institution are less likely.

Within the dominant discourse of commons, it is portrayed that the knowledge and natural commons are separate from each other. However, this case of Sahbhagi Dhan illustrates that this product constitute of both a natural resource (the plant variety itself) as well as knowledge (the trait of drought tolerance). The knowledge of drought tolerance not only comes from the techno-scientific knowledge that is the domain of the scientists, but also it had incorporated farmer's knowledge within the agronomic practices of this variety. Moreover, this variety has been developed through the PVS process where both scientific knowledge interacts with the farmer's knowledge. Therefore, we see a co-existence of knowledge systems within the development process. By accepting the contingencies associated with the farmer's knowledge and without filtering out that knowledge through scientific parameters, the development of this variety has created space for both that in certain sense complement each other.

Going back to the main research question of this paper: to what extent the variety Sahbhagi Dhan can be termed as *commons*? In summarising, it can be concluded that as far as the evolving community construction is concerned around the development of Sahbhagi Dhan, its autonomy, inclusive nature and non-hierarchical characteristics, its existence within a nebulous institutional level (distinct from state/market based institutions), and its sustenance based on plural resources, the variety can be termed as something developed through a commons based production mode, thus, can be termed as *commons*. However, the fact that both GCP and STRASA that funded the development of this variety partially claimed the entire credit for developing this variety, the fact that the variety has been registered at the NBPGR, a government of India institutions, and the fact that now the state is involved in large scale seed multiplication programme of this variety could in future create conflict in which appropriation of this variety or autonomy of the farmers in producing the seeds can happen. Further research needs to be done on in which ways this variety and its production will eventually evolve.

Chapter 6

Research Conclusions and Discussions

6.1 INTRODUCTION

Focusing on Generation Challenge Programme (GCP) drought-tolerant rice research and the development of one drought tolerant rice variety (Sahbhagi Dhan), this thesis has been concerned with the emergence of different, often opposing trends within the larger debates of knowledge production. These trends include the continuing development of an instrumental knowledge production paradigm that, backed by strong intellectual property right (IPR) regimes, is primarily steered by commercial interest towards producing utility-driven knowledge; this operates in contrast to non-instrumental knowledge production that, steered by academic interest, expresses the more traditional paradigm of a curiosity-driven search for the pursuit of truth; at the same time, however, there is also the emergence of socially organised modes of knowledge production that are based on a new commons paradigm of access, cooperation and sharing, involving open innovation models and the commons-based peer production (CBPP) mode. It is these developments within the larger discourse of knowledge production that are studied here, by empirically investigating the case of the GCP. The following general research question has guided the thesis as a whole: How do different forms of knowledge production emerge within the drought-tolerant rice research of GCP? And which practical and theoretical implications can be discerned from this?

In view of this research question, the main results of this thesis – as evident from the empirical analysis of the knowledge production process of GCP drought-tolerant rice research as well as from the analysis of the process of the development of the drought-tolerant rice variety Sahbhagi Dhan – are as follows:

- The dichotomy between the instrumental and non-instrumental knowledge production does not work as an understanding of the overall knowledge production framework of the GCP;
- A hybrid mode of knowledge production has emerged within the GCP drought-tolerant rice research composed of elements from both non-instrumental and instrumental paradigms of knowledge production alongside some elements that manifest neither of these paradigms;
- An extended and complicated version of CBPP has emerged within the knowledge production of GCP drought-tolerant rice research;
- The operation of a commons paradigm is evident within the development process of Sahbhagi Dhan that leads to the production of specific instances of commons, or common entities (thus, the development of Sahbhagi Dhan as a common).

In this concluding chapter, these findings are presented in the light of the specific research questions formulated in the introductory chapter, along with theoretical reflections pertaining to the existing debates of knowledge production, CBPP and commons. This is followed by an outline of some practical implications for agrarian knowledge production and agrarian knowledge producing institutions as indicated by these findings. Finally, the chapter ends with the theoretical implications along with the scope for future research.

6.2 SUMMARY OF MAIN FINDINGS AND DISCUSSIONS

In this section, the main findings of the different chapters are presented. These concern the generic theoretical patterns of instrumental knowledge production and their combination with non-instrumental knowledge production approaches in the practice of the GCP, the presence of an emerging hybrid knowledge production within the GCP, the extent of the CBPP mode present within the GCP drought-tolerant rice research and, finally, a reflection on the development of the drought-tolerant rice variety Sahbhagi Dhan developed by the GCP drought-tolerant RRN as a common.

6.2.1 Beyond the Dichotomy of Instrumental and Non-Instrumental Knowledge Production

Over the last few decades, the dominant knowledge production discourse has become expressed as a shift from a paradigm of non-instrumentality to one of instrumentality. There are two basic approaches to doing science, that is, which are linked to two opposing paradigms of knowledge production, and one has become efficacious as the opposite has ceased to apply. This shift has occurred because of the perceived inability of the non-instrumental paradigm to tackle complex societal problems, increasing contraction of state funding for science, massification of higher education and the emergence of proprietary regimes within academia. Within the general discourse of knowledge production, the shift from non-instrumentality to instrumentality is seen as a unilateral transition, with the assumption that the features of instrumentality are or will be present in all kinds of knowledge production programmes. Here, an analysis of various theories of instrumental knowledge production (Finalisation Science, Strategic Research/Strategic Science, Post-Normal Science, New Production of Knowledge [NPK], Academic Capitalism, Post-Academic Science and Triple Helix) reveals that the following five specific patterns can be discerned as emblematic of instrumental knowledge production*: transdisciplinarity*, *market orientation*, *networking modalities and institutional space convergence*, *direct societal engagement* and *extended peer-community validation*.

An initial analysis on the GCP knowledge production process, however, indicated problems with the application of this, both in terms of theory (the expression of instrumentalism) and metatheory (the knowledge production discourse of shift and opposition). Neither does the dichotomy between instrumental and non-instrumental

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knowledge production appear to offer an appropriate characterisation of the knowledge production process of the GCP, and, linked to this, nor does the assumption that instrumental knowledge production has in any way fully substituted the non-instrumental seem justified. Rather, the GCP knowledge production process evidences both instrumental and non-instrumental paradigms and, moreover, as in a certain sense fused. In other words, the empirical data here suggests more than just a retarded process, where the actual workings of a knowledge production process within a specific scientific set-up have just failed to keep pace with the field, since novel forms are observed that simultaneously cross the divide, that span the opposition, and therefore are adjudged to operate outside of the dichotomy. Thus, there is a more fundamental issue here with the binary categorisation; the knowledge production discourse itself requires revision.

6.2.1.1 Transdisciplinarity

Concerning the theoretical assumption of an interrelation between transdisciplinarity and instrumental knowledge production, the analysis of the GCP presented here reveals that its research approach is, in fact, strongly embedded within a disciplinary framework. The GCP tries to solve the problem of drought mainly through a broad plant-breeding trajectory. Although this includes molecular breeding and marker-assisted selection and involves also other sub-disciplines of agricultural science, such as plant physiology, biotechnology, plant pathology and entomology, along with bio-statistics and social sciences, still, it is a disciplinary rather than transdisciplinary mode of research and development that is observed; the various disciplines as listed are used to strengthen the plant-breeding approach, which is strongly discipline-bound, i.e. to agricultural science as a whole. The dual presence of practices of disciplinary embedment along with the emergence of several sub-disciplines within the GCP needs to be further explored in order to further investigate the kind of disciplinary orientation that is emerging within the GCP knowledge production. This needs to be contextualised by an examination of the whole plant-breeding approach in respect of the assumed transdisciplinary framework of instrumental knowledge production.

6.2.1.2 Market orientation

From the analysis of GCP, it became perfectly clear that GCP neither encourages a market orientation theoretically as assumed in the instrumental paradigm of knowledge production and nor does it seek or in any way foster a commodification and commercialisation of research results through the IPR regime. On the contrary, at the upstream level, the GCP aims at sharing research tools (such as molecular markers) through open source licensing (GNU, GPL and LGPL) to create global public goods for agricultural research and development, while at the downstream level, GCP products of are not patented but often registered within the public research institutions. Whether something that is developed through sharing under open-source licensing can be assumed as a global public good or for that matter can be registered within public good framework remains an open question.

It has been observed that, without a clearly stated commitment to the contrary, and especially within the more general neo-liberalising, market approach of contemporary trends in academia and science. Nonetheless, the fact remains that the GCP does not presently promote market orientation in terms of patenting or IPR and that there is no evidence at all that it has any inclination to do so in the future. Thus, the concept of market orientation appears to have no relevance to the GCP knowledge production. Therefore, this aspect very clearly stands in contradiction to the instrumental paradigm.

6.2.1.3 Networking modalities and institutional space convergence

Concerning the network modalities and the institutional space convergence, the research showed that GCP's knowledge production is organised in an international network that includes CG-centers, National Agricultural Research System (NARS) institutes, universities and NGOs. The organisation of knowledge production through this network to some extent represents the instrumental knowledge production paradigm. However, it may also be questioned whether the network development is related to the optimisation of resources or whether it is more closely related to another factor, such as the complexity of the problem (in this case drought). Although both of these are in line with the instrumental discourse, it may be revealing to see what emerges when they are distinguished as factors in the network development and relevant implications for knowledge production theory teased out.

Further issues about these networks need to be investigated for a better understanding of this aspect of instrumental knowledge production. These include how the network is created (its history), the type of institutional space that is created within the network at the interfaces of different and diverse institutions, and how non-scientific actors (particularly farming communities) are associated. To some extent, consideration of these matters will enable a more nuanced theory of network in relation to the instrumental paradigm, but more profoundly, they imply issues around the knowledge production discourse. This is particularly evident in the last point, the involvement of non-scientific actors, since it is this, the role of farmers in particular, that is raised as an issue by the more genuinely transdisciplinarity of the critical constructivist approach and which has implications for paradigm modelling – most obviously, from the perspective of instrumental knowledge production, in terms of direct societal engagement.

6.2.1.4 Direct societal engagement and extended peer-community validation

Direct societal engagement in the knowledge production process and the validation of science by the extended peer community involves non-scientific actors, including farmers as end-users. These two patterns are closely related in that they both involve those people in society most immediately affected by a knowledge production process aimed at solving a huge societal problems (drought) and validation of the technology (the drought-tolerant variety). These people (farmers) themselves comprise the extension of the peer community (of scientists) to ensure that the problem has been mitigated.

GCP's effort to make an impact at the farmer level through mediating downstream delivery can be seen as an example of instrumental pattern of organising direct societal engagement through the inclusion of end-users in the knowledge production process and the validation of science by them in or as an extended peer community. However, given the fact that the problem of drought is addressed through an advanced scientific paradigm employing cutting edge technology, the input that they – farmers – have is muted. Specifically, I would argue, the ways in which extended peer community evaluation intercedes with scientific peer community evaluation and whether and the extent to which extended peer community evaluation has really replaced the scientific evaluation needs further elaboration that may also involve the farming communities in this discussion. Indeed, the ways in which society in general can play a role in the developmental process and how society is or is not actually involved in the ongoing (bio) technology projects of agriculture is something to further reflect on.

6.2.2 Emergence of hybrid knowledge production in GCP drought-tolerant rice research

In view of the above discussion indicating problems with the application of the contemporary instrumental paradigm, as per the conventional knowledge production discourse, a more profound empirical analysis of the GCP knowledge production process was felt necessary. That is, since the standard discourse appears unsatisfactory as a way of characterising exactly what type of knowledge production is emerging within GCP and quite how different instrumental knowledge production patterns are taking different shape, further, discourse-level investigation becomes necessary.

The results of the empirical analysis of the GCP drought-tolerant rice research reveals that its knowledge production process follows neither an instrumental nor a non-instrumental discourse in absolute (pure) terms. It is *hybrid* in nature, as it has elements of both paradigms, but which also take different shape alongside some elements that belongs to neither of these, as explained below in a review of the five specific patterns emblematic of instrumental knowledge production.

6.2.2.1 Transdisciplinarity

As far as the disciplinary orientation of this research network is concerned, the research practice of the GCP drought-tolerant rice research appears to be different from that assumed in the various theories about instrumental knowledge production built upon a transdisciplinary approach (Funtowicz and Ravetz 1993, Gibbons, Limoges, and Nowotny 1994). Instead of a transdisciplinary approach, the GCP research illustrates rather the application of a rather disciplinary, plant-breeding approach, albeit executed through cooperation among a range of various specific (sub-) disciplines. These (more specifically their representatives, the scientists involved) were all committed to developing a plant-breeding solution to and thus understanding of the drought problem, but perceived from different perspectives, insights, data, concepts, theories and methods as related to that particular (sub)discipline of the plant breeding framing of the drought problem in which they had specialised. The evidence presented in this thesis has shown that these different plant-breeding sub-disciplines work together within the GCP rice project aiming to understand the scientific as well as implementation complexity of the drought problem – but perceived from within the confines of this particular plant-breeding framework, which represents a disciplinary integration that does *not*, in my opinion, transcend disciplinary boundaries so as to qualify as importantly *trans*disciplinarity.

As a matter of fact, complex scientific problems (such as drought) often require the application of advanced cutting-edge technology (e.g. using molecular markers) in an advanced science (genetic engineering) that is embedded strongly in a particular disciplinary structure (agricultural biotechnology, or agri-tech). This is qualitatively different from the transdisciplinary approach, however, which mobilises a range of theoretical perspectives and practical methodologies to solve problems that are not necessarily derived from pre-existing disciplines or formative of new disciplines. Overall, it can be concluded that the disciplinary orientation of GCP drought-tolerant rice research is *inter*disciplinary in nature, as there is integration among several (sub-) disciplines leading to a strengthening of the plant-breeding approach; examination of the GCP case reveals an interdisciplinary rather than transdisciplinary model, one may say. Therefore, the disciplinary orientation of GCP drought-tolerant rice research does not strictly conform to the either paradigm of the knowledge production discourse; however, given the dominance of several disciplines and its integration process, it seems more inclined towards the non-instrumental paradigm.

6.2.2.2 Market orientation

The second assumption of an instrumental knowledge production and the associated discourse is that science has an increasingly strong market orientation, particularly through the commodification and commercialisation of research results. As outlined (above), analysis of the GCP drought-tolerant rice research shows that the development of the Sahbhagi Dhan variety has taken place within another context, other than that of commodification through the acquisition of patents, which represents the dominant trend in the contemporary scientific establishment (Atkinson et al. 2003, Purkayasthsa 2011). At a time when the whole patent and IPR regime is being severely criticised as involving harmful restrictive practice – for example, by confining science to a select few (Heller and Eisenberg 1998) – this case shows that there are many researchers who clearly take the position that everybody ought to enjoy an equal right to the benefits of science, since they freely (and voluntarily) work for that.

Indeed, these scientists take an ethical, humanistic stance, advocating that science has a role to play in making life better for the underprivileged and disenfranchised, and, thinking specifically of agriculture, for the resource-poor population at large. In this sense, they may be considered activists, in a socio-political sense. The products of the RRN with which they work – which they constitute – are deliberately made open to all who want to use them for cultivation and further research and development. In this sense, the knowledge production of GCP drought-tolerant rice research very clearly conforms to the non-instrumental paradigm, in which science is not seen from a commercial perspective.

6.2.2.3 Networking modalities and institutional space convergence

This research has showed that the GCP rice research is organised within a network that has emerged to focus on solving a specific societal problem (drought). This RRN has been evolving over last 20 years through repeated interactions between an extended list of institutions (Thune and Gulbrandsen 2011), and what has evolved is not a single institution directing research, but rather the *hub* of a *supra-institutional organisational entity*. Knowledge production in this supra-institutional organisational entity is carried out in non-hierarchical, heterogeneously organised forms that are essentially transient (Gibbons, Limoges, and Nowotny 1994). Within this arrangement of knowledge production, actual institutional spaces are blurring into each other and creating an institutional hybridisation (Etzkowitz 2001, Etzkowitz and Leydesdorff 2000).

Insofar as the research is conducted through international supra institutional organisational entity to solve a particular problem (namely drought), the network structuring aligns with an instrumental approach analysis. However, the research carried out in this network does not aim to optimise resources as argued in the framework of instrumental discourse, but only to tackle a complex problem through reducing the G*E interactions (by conducting trials in various agro-ecological zones). The failure to meet the efficiency demand – or rather, the non-factoring of this into the organisational arrangement of this research (the RRN) – may be deemed somewhat incidental to the discourse (the reading of this case as expressive of the instrumental paradigm and thus supportive of the transition from the non-instrumental). On the other hand, it does invite alternative conceptualisations, especially in tandem with the other issues raised.

6.2.2.4 Direct societal engagement

Regarding the direct societal engagement (through inclusion of end-users) within the knowledge production process – an essential feature for the instrumental discourse, unlike the non-instrumental discourse, in which science is guided by the scientific establishment alone (Gibbons 1999, Gibbons, Limoges, and Nowotny 1994, Gibbons 2000) – this research showed that the end-users (farmers) are involved not as an upstream stakeholders but as an extended community at the peripheral level to eventually judge, use and validate the scientific products. This research has also shown, however, that farmers are generally little interested in or capable of guiding science at the upstream end of development. Confronted with the presentation of drought as a complex scientific problem that requires the application of advanced science employing cutting-edge technology, the farmers see no role for themselves in formulating the agenda.

Therefore, it can be concluded that, in this matter, the GCP drought-tolerant rice research certainly does not follow a non-instrumental discourse – but it does not follow an instrumental discourse either (Kurek, Geurts, and Roosendaal 2007), as the end-users (farmers) are only involved in legitimisation of scientific research and not as a serious stakeholder steering or guiding science, as claimed in the instrumental discourse. Again, we conclude, the evidence here, the involvement of farmers at the peripheral level of knowledge production, can also open up a space for other possibilities, for other debates within the knowledge production discourse.

6.2.2.5 Extended peer-community validation

This brings us to the final organising principle of knowledge production, concerning the standard discourse of a change-over to *validation of scientific knowledge by interested parties and society at large* in the instrumental paradigm from the non-instrumental paradigm peer-community validation (Funtowicz and Ravetz 1993, Gibbons 1999, Gibbons, Limoges, and Nowotny 1994). Indeed, the analysis presented in this thesis shows that validation of research product was not only performed by the scientific community (academically trained experts), but also by the end-users, the farmers as practitioner experts.

However, the fact that the validation of scientific research is increasingly performed by extended peer communities or end-users at large does not in itself radically undermine the role of scientific validation as performed by the scientific community. For example, research proposals awarded by the GCP are basically evaluated by members of this group. Scientists often write research articles that are also reviewed by fellow scientists, while funding and other plans and any proposals are adjudicated by organisations whose members include scientists among their numbers but not farmers. Therefore, contrary to the claim of the standard discourse describing the dominance of the instrumental paradigm, validation by an extended peer community has not replaced the scientific validation process or methods, but has rather supplemented and extended it. Scientific community validation still is very important for the scientific community, but increasingly in a way that acknowledges the importance of extended peer community evaluation.

In view of this discussion, it can be stated that within the knowledge production of GCP drought-tolerant rice research, along with an extended version of instrumental knowledge production, other features and trends (including those aligned to non-instrumentality) needed to be analysed. These include the non-material motivations of scientists, involvement of society at the peripheral level and functioning of the network, and the proposal is to do this from alternative knowledge production models, such as the CBPP, invoking an alternative paradigm, that of the commons. Thus, the following section summarises the results of the analysis of GCP drought-tolerant rice research from the CBPP perspective.

6.2.3 Emergence of an extended and complex version of CBPP within the GCP research

The result of this thesis indicates that characteristics of the CBPP mode as investigated by Benkler (2004, 2006) for software of *modularity*, *fine granularity*, and *low-cost integration* along with a *decentralised organisational base* and *participation in the production process for a social cause* rather than material reward are also present in the organisation of the knowledge production of GCP studied. Some aspects of GCP drought-tolerant rice research are similar to the CBPP mode of the software arena, while other aspects take different and extending forms.

First, regarding modularity, it is observed that the GCP knowledge production is organised in several institutions located in different agro-ecological zones. This geographically framed compartmentalisation of agrarian knowledge production reflects the modular approach of the CBPP mode. However, within the software arena, as explained by Benkler, the main goal of modularity is to divide the work between as many groups as possible so as to raise the number of people contributing to the production process. For the GCP-RRN, conducting the knowledge production in different agro-ecological sites is basically aimed at achieving reductions in the environmental effect within a comparatively small time and incorporating local- and context-specific needs within the larger framework of technology development to attune technology (Ruivenkamp 2005, 2008, 1993). In this case, the modularisation of work stems from the very nature of the *agrarian knowledge production*, in which there is a material need for modularisation due to *agro-ecological considerations*. The modularisation here, of various work-sites and institutes located in different ecological zones, is related to the material requirement of establishing a linkage of a drought-tolerant rice variety to its environmental setting, for which each scientific (sub-) discipline delivers its own specific contribution within the framing of a plant-breeding approach.

Second, while in the software arena the granularity of the modules is based on the different level of contribution of each individual participant, depending on his/her different level of capacity and motivation, which emphasises the small-scale of contributions, this case is characterised by an extended heterogeneous granularity built not only on the differences in actor sizes/types (institutional, as well as individuals), but also in disciplines and ecological zones (and the inter-relationships of these) and, of course, in the resource origins (plants, DNA, within the plant-breeding framing of the drought problem). Thus, whereas granularity in the software realm consists basically of one or two dimensions (individuals' capacity and motivation) and is characteristically fine (small contributions), in the combined soft/hardware arena of agrarian production it is multi-dimensional (regarding institutions, disciplines and zones, as well as plants), and variably-sized, including fine-grain oriented. We may come to a similar heterogeneous, granular conclusion, therefore, but characterise software production in terms of small-scale heterogeneous granularity and the agrarian in terms of a *multi-grained institutional, multidisciplinary and resource heterogeneous granularity*.

Third, the working culture within the GCP drought-tolerant rice research resembles other commons-based networks (Benkler 2006). The working relations and organisational practices are *loosely structured*, *strikingly democratic*, *non-hierarchical* and based on *consensus-building* through debates and discussions, unlike the very structured and bureaucratic organisational practices of the originating institutions (such as the *Indian* Council of Agricultural Research [ICAR] or CGIAR) from where the scientists are coming (with whom they are employed). These relations of partnership are also extended to some extent to the farming communities who are participating in the knowledge production process.

Fourth, an important feature of CBPP is that it facilitates the sharing of resources both material and immaterial within its members without much in the way of proprietary obligations. Commons-based approaches thrive on sharing rather than confinement to a selective few (Benkler 2002, 2006, Benkler and Nissenbaum 2006). This is the reason that many scholars have insisted on a sharing of plant genetic resources (PGRs), since imposing strict IPRs in agriculture that could deter innovation. Indeed, of course, the diversity of plant genetic resources we enjoy today is largely the result of thousands of years of a free flow and sharing of these resources.

This thesis observed that the RRN allows sharing of breeding material without any legal obligations – even without material transfer agreements (MTAs) – between diverse sets of institutions (such as ICAR institutes, agri-universities, NGOs and international agencies of differing kinds). Moreover, the knowledge production process, especially at the upstream level, has been found to use several biotechnological tools (such as marker-assisted selections and marker based technologies) in common. These technologies often came under the purview of IPR, but the GCP always committed to make these technological tools available without any IPR obligations. This illustrates that the idea of the *sharing of technological codes* is embedded within the larger framework of GCP. The sharing of resources generally makes much sense when it is done through diverse sets of actors.

In the software arena, new commons, particularly digital commons, are created through the CBPP mode of production. As it is clear that a *complex and extended CBPP mode* is emerging, we may refer to a *hybridised common*, one that includes both the software (genetic code) as well as the hardware (seed, plant variety). Therefore, it is important to investigate a product of this GCP drought-tolerant rice research to find out if it can be considered as a common. To this end, the process of the development of Sahbhagi Dhan (as a product of this GCP drought-tolerant rice research) is analysed to see the extent to which this variety can be termed a common.

6.2.4 Emergence of the process of commoning to produce a common

The final and the most challenging result of this thesis is that the drought-tolerant rice variety Sahbhagi Dhan developed within the GCP research can be perceived as a common. More precisely, it is a *hybridised common* composed of both a *physical component* (the tangible one, for example the crop as such) and an *informational component* (an intangible one, for example, particular drought-tolerant traits that have been inserted into the crop). This drought-tolerant variety is a common because it has been developed through a process of commons as explained below and because it stands outside of propriety regimes (it is not owned, as property). Another result derived from this is the idea that to call a product a common, it must be developed through a *process of commoning* in which the product and the process through which it is developed are intertwined and mutually exclusive. The following features of this process of commoning are discerned from the empirical analysis of the development process of the Sahbhagi Dhan variety.

First, the development of Sahbhagi Dhan was the common result of *cooperation* among various stakeholders which, in the development process, created a network. Therefore, this research network can be seen as the social structural product of a *research community* or *community of practices* (COPs). This community was not constructed by any single institution but emerged as part of a network that had been evolving over the last 20 years, and in that sense is still under permanent construction, as, after the termination of the GCP research projects in 2014, the community continued. It is currently sustaining itself through the Stress-Tolerant Rice for Africa and South Asia (STRASA) programme and continuing its research for drought tolerance (Ruiz-Ballesteros and Gálvez-García 2014).

Earlier studies have stressed that a discussion on commons is incomplete without community, although without, however, explaining the various internal relations of such community (Caffentzis 2008, Mies 2014). Here, these have been detailed for the GCP-RRN, from historical and geographical perspectives of institution and personnel, in terms of the shared aim of working with the complex problem of drought to develop drought-resistant varieties, or for a specific resource creation. This thesis tentatively concludes, therefore, that development of a *community-building process* based on *shared practices* in relation to *resource creation and/or management* is or at least may be the first aspect to look for when taking a commons-based production perspective (Ruiz-Ballesteros and Gual 2012). The very fact that the community is evolving with the resource creation itself denotes a degree of process of commons.

Second, it is evident from the analysis that this research community is *autonomous* despite being located in several overlapping bureaucratic institutions, such as ICAR and CGIAR. This research community is autonomous because it maintains its research agenda and research practices without any interference from the umbrella institutions alongside which it is situated. The autonomy of the community is also reflected within the internal dynamics of this community, which is *non-hierarchical*, *horizontal*, and *inclusive* in nature, a striking feature of commons in general and commons-based production in particular (Harvey 2012).

Also important, the *work culture* of this research community is based on discussion, debate, and consensus-building regarding the research planning and approach. In a certain sense, the research activities of this community are developed within a *bottom-up flow*, whereby individual actors participated in developing the initiative of a research community network. Scientists who participate in this research community are doing this without any structural obligations from their respective institutions. This *volunteerism* and willing participation of scientists contributed towards maintaining individual as well as the collective autonomy of this research community. It is an imperative for any commons-based production to *organise its own internal dynamics* in a non-hierarchical, horizontal and inclusive way (Harvey 2012), as was the case for this particular research community.

Third, another feature that is observed in this research network is that of the *plurality* around which the network is built. There are mainly three types of plurality involved in this network: plurality in actors (both individual and institutional), in disciplinary activities and in material resources (in terms of funding). Regarding actor plurality, this community has been organised within several national and international research institutes, universities, NGOs and local farmer's organisation, comprising several individual actor types (scientists, professors, administrators, extension workers and farmers). Regarding disciplinary plurality, the research approach of this community is embedded within an interdisciplinary framework that consists of several disciplines, such as plant breeding, biotechnology, statistics and plant physiology, and social sciences. These disciplinary activities work in an intertwined and integrated manner to approach the drought problem. And regarding the material (financial) resource required, this community-building process has been sustained through diverse sources; initially, the funding was provided by the Rockefeller Foundation (RF), then the Generation Challenge Programme (GCP), and now from the Bill & Melinda Gates Foundation (BMGF).

However, apart from this research funding, regular recurring costs, such as the salaries of the researchers and research infrastructure expenses are borne by the respective (employer and owner/renter) institutes. This, in fact, has enabled a freedom from any single source, thereby facilitating community autonomy. Therefore, this thesis concludes that this research community has thrived in conditions of *actor, discipline and resource plurality*, in which it has successfully created an independent platform for sustained co-existence among diverse participants and practices for a common objective (Cheria and Edwin 2011b, De Angelis 2014, Öztürk, Jongerden, and Hilton 2015).

And finally, although this research community is situated in an overlapping institutional sphere of state, business and international institutions, it is itself neither public nor private in nature. This research community cannot be demarcated as a legal entity or identified through the state vocabulary. It exists as a confluence of plural activities through collective action towards a common goal, and it can be seen as a *shared enterprise* in which *shared action* generated the process through which the unpatented or otherwise owned Sahbhagi Dhan variety was developed and from which simultaneously actors benefited through participating in that shared process. Thus, the product that comes out from this process is neither public nor private in nature, but it is *a common*. It has been developed through shared action, as a *process of commoning*, and no single institution can claim exclusive right over it. Therefore, the *non-state and non-market character* of the research community becomes an essential feature (Deneulin and Townsend 2007, Hollenbach 2002, Öztürk, Jongerden, and Hilton 2015).

In summarising, it may be concluded that as far as the evolving community construction is concerned – at least as evidenced around the development of Sahbhagi Dhan – its autonomy, inclusive nature and non-hierarchical characteristics, its existence within a nebulous institutional level (distinct from state/market based institutions) and its sustenance based on plural resources, the variety can be regarded as something developed through a commoning process and thus termed a common. Standing outside the private-public divide, it may be noted, the notion of commons stands outside a conventional dichotomy of political economy – and, moreover, in an a-oppositional way that parallels the idea of the common as a knowledge production paradigm which stands outside the non-instrumental to instrumental shift (thus opposition). Theoretical considerations arising from this work are considered below, after the following section on practical implications.

6.3 PRACTICAL IMPLICATIONS

The following practical implications can be discerned from the emergence of a hybrid knowledge production mode, a complicated and extended CBPP mode and the process of commons for agrarian knowledge production and agrarian knowledge producing institutions such as NARS and CGIAR.

First, as is evident from the previous sections, an *alter-institutional space* has been created within the actual institutional space of NARS and CGIAR, which itself is often marked with entrenched scientific bureaucracy based on top-down managerialism. As this alter-institutional space is characterised by a decentralised organisational base, voluntarism, non-proprietary developments and social motivations, scientists are enabled to actively pursue innovative, socially relevant research along with scientists from several other organisations that can complement the research scope of NARS and CGIAR. For instance, the case studied here showed that drought-tolerant rice research was initiated within this alter-institutional space long before ICAR understood the importance of drought research and while ICAR lacked the capacity to engage with drought research anyway. Therefore, NARS (in developing countries) should allow flexibility within their frameworks to allow scientists to create such spaces to conduct their own research agenda.

Second, as it is evident from the previous section, PVS has created a *social space* within the *peripheral level of the knowledge production process*. Within this social space, the scientific community interaction with the farming communities offers possibilities to tailor or attune technology for context-defined specific needs. This social space manifests a middle-ground route that allows a negotiated approach for technology adoption and dissemination. Therefore, the creation of such social space must be encouraged within the mainstream agrarian knowledge production process to go beyond a black-and-white acceptance-versus-rejection approach to agricultural technologies. Moreover, the creation of this social space through PVS can help farmer-to-farmer extension, support multiplication of newly developed seeds prior to government seed multiplication programmes and create conditions through which different knowledge systems interact with each other to make a coexistence of practice that is beneficial for overall agrarian knowledge systems.

Third, the modular organisation of knowledge production process through *different agro-ecological zones* leads to the debate of the *reconnection of agriculture with local needs*. Many authors have passionately argued for the need for reconnection but insufficiently indicated how and in which way reconnection can be realised (Louwaars 2007, Pretty 2002, van der Ploeg 2008, Falcon and Fowler 2002, Kloppenburg 2010a, b). From this case, it can plausibly be stated that the reconnection debate in agriculture needs to be started with the way agrarian knowledge production is organised. For example, while researching complex scientific problems in rice, particularly submergence and salinity, conducting the research within an agro-ecologically diverse set up can help in understanding complexity (different manifestations of this problem in different places) and provide structural restrictions (to analyse and overcome the genetic and environmental interactions within a limited timeframe).

Fourth, as it is clear that the knowledge production of drought-tolerant rice research is also characterised by a *heterogeneous granularity* in actors, disciplines and resources that goes beyond the fine granularity in the software arena based upon the differentiated, small-sized contributions of the individuals dependent on their various capacities and degrees of motivation, various implications may be drawn for related *organisational principles*. As in the software case, this heterogeneous granularity of agrarian production makes it essentially impossible for any single module/contributor (individual or institute) to appropriate and claim ownership of the rice varieties produced. It is thus another important feature of the heterogeneous granularity of the agrarian production system is that *no single entity can hold an exclusive right to the end product*.

The particular way in which the GCP-RRN development and production of drought-tolerant rice variety was socially organised – with heterogeneous (multi-disciplinary and agro-ecologically and work-site specific) settings and (individual and institutional) contributors – stimulates an approach of sharing and integrating all these different contributions towards a common goal. Indeed, many scholars (Deibel 2013, Kloppenburg 2010a, Lemmens 2013, Kloppenburg 2014, 2010b) have insisted on this as a *practice of sharing* plant genetic resources, as opposed to the imposition of (strict) intellectual property rights. In this respect, this case already stands as a model for similar network development, since it is built upon practices of sharing the breeding material without any legal obligations between the diverse set of institutions as well as a common usage at the upstream level of several biotechnological tools, such as marker-assisted selections and marker-based technologies.

Finally, the knowledge production process of drought-tolerant rice research is built around plurality as has been indicated. The practices of plurality are very important with in commons based production as it negates the ownership debate in relation to the resource in hand. Commons that are created are always vulnerable to enclosure, but the more plurality is present in the production process, the more possibilities to appropriation are less likely or cumbersome. Moreover, along with plurality, the reliance and incorporation of an intrinsically motivated labour input acts as a bulwark against proprietary regimes and the appropriation of the knowledge product, most obviously in the form of variety patenting. It may be, therefore, that this specific social organisation of agrarian knowledge production will contribute to a new trajectory of commons-based production systems.

6.4 THEORETICAL IMPLICATIONS AND SCOPE FOR FUTURE RESEARCH

The following theoretical implications and scope for further research conclude this thesis. First, the thesis has challenged the discourse of a unilateral transition of knowledge production from non-instrumentality to instrumentality, as the drought-tolerant rice research of GCP showed that a hybrid model of knowledge production has emerged that has elements from both these paradigms of knowledge production. In view of this, there is a need to question different organising principles of knowledge production – such as those here identified (transdisciplinarity, market orientation, networking modalities and institutional space convergence, direct societal engagement and extended peer community validation). This needs to be done not from the oppositional discourse of an instrumental to non-instrumental paradigm shift, but from a perspective of blurring of the two to find out *why* such shades of grey are emerging.

For example, why do we see the growth of networking modalities within the knowledge production process? Is this only intended for optimising resource use or is it the very nature of scientific complexity associated with problems such as drought (and submergence and salinity) that pushes the organisation of knowledge production towards an agro-ecologically diverse network set-up? This type of question can be further taken up by analysing GCP's involvement with other crops (wheat, maize, cassava, sorghum etc.) in other regions (Africa, South America, etc.). Findings from such studies may reinforce or add to the findings of this thesis.

Second, in relation to the findings of this research, it is observed that GCP aimed at tackling the problem of drought through the biotech plant breeding trajectory. Other options such as the intensification, development of better root structure or development of agronomic practices received less or no attention. Then, the sharing in this trajectory of biotechnological tools, held and accessed as commons, involves assumed rather than considered practice. Therefore, further investigation is required into whether the sharing of resources and tools might serve to strengthen an exclusive use of the plant-breeding framing of, for example, the drought problem and thereby serve to reinstall new power relations around the institutions involved (in the approach to specific problem solutions), or, on the contrary, whether this sharing may in fact (continue to) open perspectives for more *egalitarian, democratic and diversified trajectories of knowledge production*.

Third, it is shown in this thesis that the variety Sahbhagi Dhan was developed through a commons-based approach, but, the registration of this variety at NBPGR and the potential for its later conversion into public goods also allows for the possibility that the affective (voluntarily given) labour might later become utilised for private gain. Insofar as both of these (commons or capital oriented) trajectories remain open for future development and either may be emphasised for the future, it becomes crucial to follow the ways in which the social relations between scientists and farmers in developing the pure breeding lines evolve. This implies a commitment (activism) to the second, commoning trajectory on the part of different actors (including advocacy groups working at all levels and the farmers and scientists themselves). This will need to focus, among other things, on *future working structures* and the *emerging network power relations*. It may eventually have to concentrate energies also on whether and how new public/private proprietorial claims can be challenged.

Fourth, the fact that both GCP and STRASA claimed the entire credit for developing this variety ignoring the historical process and the fact that now the state is involved in large scale seed multiplication programme of this variety could create conflict in the future. It is entirely possible to imagine an appropriation of this variety or restriction of the autonomy of farmers in producing the seeds. Further research needs to be done on in which ways this variety and its production will eventually evolve and how such *anti-commoning dangers* may be averted.

Fifth, this thesis revealed key features that should be taken into consideration when conceptualising the concept of *commons as production system* (as opposed to the governance or management of shared natural or knowledge resources). One of the key features of commons as production system is that the ability of this concept to go beyond the realms of state and market, of public and private or some public-private in-between arrangement. This research has shown that a flexible and dynamic institution was created that cannot be strictly demarcated as either public or as private, because it cannot be demarcated as legal entity. Further, research on the concept on commons is required to reflect on what constitutes something as non-state and non-market to elaborate on the particular social relations that are crucial in such an understanding of commons.

And finally, the distinction between knowledge commons and natural commons as separate entities as often portrayed within the dominant discourses of commons seems not an appropriate frame of reference with which to understand the concept of commons as production systems. The case of Sahbhagi Dhan illustrates that this product constitute of both a natural resource (the plant variety itself) as well as knowledge (the trait of drought tolerance) that makes it a hybridised commons in which techno-scientific knowledge as well as farmers' practices co-exist. Therefore, as we move in general towards a knowledge economy and knowledge society, further research is necessary on how certain natural resources have a certain knowledge component (historical contingencies of knowledge) and how both these (knowledge and natural) components can combine to construct the *hybrid commons*.

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SUMMARY

The discourse on knowledge production is in constant transformation: on the one hand, there is the emergence of instrumental knowledge production based on scientific utility and socio-economic relevance and marked by property regimes, while on the other hand, there is another form of knowledge production based on cooperation, communication and the sharing of knowledge often entitled the open-source production or commons-based peer production (CBPP) mode. Both these trends are reflected partially or in full measure within the agrarian knowledge production programme called Generation Challenge Programme (GCP).

Created by the Consultative Group of International Agricultural Research (CGIAR), the GCP is an international knowledge production platform that aims to use plant genetic diversity to develop technologies to support plant breeders in developing countries. In this work, it employs advanced genomic science and comparative biology in order to develop improved plant varieties for harsh, drought-prone environments. It focuses both on conducting advanced upstream researches with the help of genomics, molecular biology and bioinformatics and also on facilitating the downstream delivery of this research result to the farmers' field. GCP's knowledge production is organised in an international network that consists of CGIAR research centres, National Agricultural Research Systems (NARS) institutes, Advanced Research Institutes (ARIs) and other developmental organisations. The overall framework of GCP's knowledge production is embedded in a global public goods framework, although the GCP also uses open source software to share knowledge regarding different biotechnological tools that usually comes within the purview of intellectual property rights (IPR).

Clearly, GCP's knowledge production is mediated through a variety of patterns that may compete as fundamentally contradictory. It becomes important to study the knowledge production process of GCP, therefore, so as to understand the type of knowledge production that has emerged there and the implications of this for the wider debates on agrarian knowledge production. Three theoretical concepts are employed to frame analysis of the knowledge production of the GCP in this thesis: instrumental and non-instrumental discourse, CBPP and commons. And to this end, drought-tolerant rice research in the Indian context is used as a case study.

In Chapter 2, the discourse on knowledge production is introduced as comprised by two approaches, the non-instrumental and instrumental, with a shift over recent decades from former to the latter generally perceived as an inevitable transition. This chapter first provides an account of the characteristics of the non-instrumental knowledge production approach and then of its gradual shift towards an instrumentality approach. The shift

has taken place, it is argued, because of the inability of non-instrumental knowledge production to deal with complex and wicked problems, the general contraction of available funding from the state to conduct basic research and the massification of higher education leading to the development of a society, particularly in the West, that is able (sufficiently well informed) as well as willing to confront the scientific establishment.

Next, the instrumentality approach is elaborated with an overview of some of the main theories through which different characteristics of the instrumentality approach have been expressed, namely Finalisation Science, strategic research/Strategic Science, post-normal science, new production of science (NPK), Academic Capitalism, post-academic science and Triple Helix. Five common patterns derived from these various theories and considered emblematic to the instrumentality knowledge production approach are then outlined – these being transdisciplinarity, direct societal engagement, market orientation, networking modalities and institutional space convergence, and extended peer community validation. Following that, some critical questions are asked regarding these basic tenets of the instrumentality discourse, in addition to the already existing criticism of that knowledge approach. Finally, the chapter ends with a research agenda for further empirical investigation to reflect on possibilities for going beyond an instrumental discourse on agrarian knowledge production.

Chapter 3 opens with a detailed background of the GCP, which is followed by an elaboration on the scientific complexity of the problem of drought. This is followed by a description of how the GCP has approached the issue. This chapter also provides the methodological considerations of taking the case of drought-tolerant rice-variety development in the Indian context as a central focus for this thesis. Thereafter, this chapter analyses the drought-tolerant rice research case in the light of the five patterns identified in the previous chapter. With in-depth empirical analysis, this chapter shows that a hybrid knowledge-production paradigm has emerged within the GCP rice research network that has elements of both the non-instrumental and instrumental approaches to knowledge production. Further, this chapter also illustrates the implications for such hybrid knowledge-production discourse for agricultural research and development.

In Chapter 4, the knowledge production process of the GCP (in the same case of drought-tolerant rice research) is analysed from CBPP theoretical perspectives, introducing the idea of a different mode of production system conceptualisation. The CBPP mode described as organised in a decentralised manner and based on collaboration between individuals who are either motivated by social causes or dependent on indirect forms of rewards. It has three structural attributes: modularity, granularity and low cost integration. Developed by observing the trends of free and open-source software production, the concept of CBPP is here extended through analysis of the knowledge production of drought-tolerant rice research to the broader study of agrarian non-

ICT-mediated knowledge-production systems. The chapter concludes that the main characteristics of the CBPP mode in the software arena are also manifest in the GCP drought-tolerant rice research case, but taking a rather different shape.

It is argued here that the *modularisation* of knowledge-production work is not primarily based on a division of work of the individual contributors but rather stems from the very nature of agrarian knowledge production, since there is a material need for modularisation regarding agro-ecological considerations. This knowledge production is also characterised by a *heterogeneous granularity* in actors, disciplines and resources that goes beyond the granularity in the software arena based upon the differentiated, small-sized contributions of the individuals involved and dependent on their various capacities and degrees of motivation. There is a combination of decentralised organisational base, volunteerism, non-proprietary developments and social motivations that is related to the emergence of a specific CBPP mode of agrarian production. This chapter ends with a consideration of the wider relevance of the emergence of the CBPP mode in agrarian knowledge production for agrarian knowledge systems.

Chapter 5 is based on an empirical study of the development process of a drought-tolerant rice variety, Sahbhagi Dhan, which was the result of a twelve-year long collaboration between the International Rice Research Institute (IRRI) and other different Indian institutions. The main aim of this chapter is to understand the extent to which the drought-tolerant plant variety Sahbhagi Dhan can be considered a *common*. This chapter applies a critical constructive approach in which the dominant discourse on commons is critically reviewed and then applied to the empirical analysis on the development process of Sahbhagi Dhan. A constructive framework on commons is thus developed in which some key aspects of commons as production system are suggested (wherein ‘production’ has a general – material, cultural, etc. – reference rather than one specific to knowledge). This framework is analysed as an interwoven process of community building involved in the production of commons. The chapter concludes that as far as the evolving community construction around the development of Sahbhagi Dhan is concerned, its autonomy, inclusive nature and non-hierarchical characteristics, its existence within a nebulous institutional level (distinct from state/market based institutions) and its sustenance based on plural resources mean that the plant variety can be considered as something developed through a commons-based production mode – and thus, can be termed a common.

In this concluding chapter, firstly, the findings presented Chapters 2 to 5 are summarised in the light of the specific research questions that are asked in the introductory chapter. Then, these findings are reflected upon and linked to the existing debates on agrarian knowledge production, particularly from the theoretical perspectives of knowledge production discourse, commons-based peer production and commons that guided the thesis as a whole. This is followed by an indication of some policy implications for international agricultural research that emerge from this research. Finally, possible areas for future research are identified.

In the light of the findings of the GCP drought-tolerant rice research in the Indian context and the development of the drought-tolerant rice variety Sahbhagi Dhan as presented in the previous chapters, it can be concluded that the knowledge production that has emerged is hybrid in nature, wherein different trends of knowledge production approaches, CBPP and commons have converged. This convergence has resulted a new meaning or shape being given to the existing understanding of knowledge production patterns. This chapter also indicates several implications of the emergence of this hybrid knowledge production for agrarian knowledge production and agrarian knowledge producing institutions, and it ends with a brief detailing of future research perspectives.

ACKNOWLEDGEMENTS

‘It is lovely to be silly at the right moment.’ – Horace

With due apology, may I take the liberty of using the words of the great poet Horace more than many centuries ago and say how lovely it is to be not only silly but also confused at the right moment. And I solicit both a little bit of silliness and a quite a bit of confusion in taking this to be the right moment. Without silliness, I doubt if I would have ever dared to endeavour to pursue a PhD, and my confusion is the inadvertent consequence of that silliness. It was over five years ago that I started this PhD, seeking clarity and hoping that a clear stream of reasoning would evolve in resolving my conceptual and empirical confusions. A clear stream of reasoning did, indeed, evolve, as reported in this thesis; however, instead of ushering in the clarity I aimed at, it left me today with more confusion than I had when I started. This ascension level of confusion has been shaped in numerous ways by some brilliant minds to whom I here extend my sincere appreciation.

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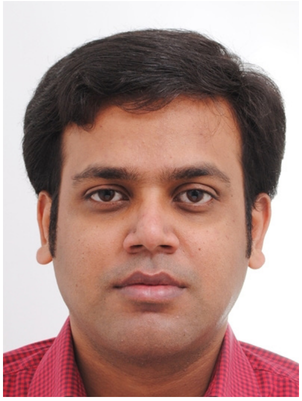
Wageningen

International Women's Day, 2016

ABOUT THE AUTHOR



Soutrik Basu was born in Bardhaman, India on 8th January 1985. Initially, Soutrik pursued a Bachelor's degree (*B.Sc*), between 2003-07, in Agricultural Sciences from Allahabad Agricultural Institute – Deemed University, India that was followed by an international Master's programme (*M.Sc*), between 2007-09, in Management of Agro-Ecological Knowledge and Social Change (MAKS) [later renamed as Development and Rural Innovation (MDR)] from Wageningen University and Research Centre, the Netherlands. Soutrik was awarded with the prestigious Wageningen University Fellowship by the Executive Board of Wageningen University and Research Centre, for his outstanding performance in bachelor's study, to pursue his *M.Sc* at Wageningen University.

Soutrik started his PhD research at the erstwhile Critical Technology Construction (CTC) that later merged into the Sociology and Anthropology of Development (SADE) cluster of Wageningen University, the Netherlands in August 2010. During his PhD studies, Soutrik became the member of the Employees Council (EC) of Social Sciences Group. Soutrik also won the competitive research grant from WASS to become a visiting research scholar at the Department of Community and Environmental Sociology at University of Wisconsin-Madison, USA. Soutrik is a nomad by nature and is a passionate cricketer. Some of his other interests are history, politics, and cinema. Soutrik would like to become either a cricket commentator or a film director in future.

TRAINING AND SUPERVISION PLAN

Soutrik Basu

Wageningen School of Social Sciences (WASS)
Completed Training and Supervision Plan

Name of the learning activity	Department/Institute	Year	ECTS*
A) Project related competences			
Writing PhD project proposal	WUR	2010	6
Investigating technology, politics, power and the social shaping of technology	WASS, WUR	2011	4
Introduction to commons, collective action & property rights	IASC workshop, Hyderabad, India	2011	0.3
Communication in Interdisciplinary research	WGS, WUR	2012	1.1
Critical Perspectives on social theory	WASS, WUR	2013	2
Interpretative methods and methodologies	WASS,WUR	2013	4
B) General research related competences			
Information literacy PhD including Endnote Introduction	WUR Library	2010	0.6
Presentations related to PhD (proposal, preliminary findings, chapters of dissertation)	CTC/SADE/RSO, WUR	2010-2015	2
Scientific publishing	WGS, WUR	2011	0.3
'Open Source, Commons, and Development: A research agenda on Common Pool of Services of Generation Challenge Programme (GCP)'	13th International Conference Proceeding IASC, Hyderabad, India	2011	1
'The spread of System of Rice Intensification above farmer level in Andhra Pradesh, India'	International Conference Innovations in Extension and Advisory Services, Nairobi, Kenya	2011	1
'Community, Conflict, and Land: exploring the strategic partnership (SP) model of South African land restitution'	International Development Conference: Integrating Research, Policy and Practice, University of Auckland, New Zealand	2012	1
Essentials of scientific writing and presenting	WUR Language services	2013	1
'Towards Commons-Based Knowledge Production: A case of drought tolerant rice research in India'	14th Global Conference IASC, Mount Fuji, Japan	2013	1
'Extending the Commons Based Peer Production to study agrarian knowledge production: the case of Generation Challenge Programme'	2nd Thematic Conference on Knowledge Commons: governing pooled knowledge resources, New York, USA	2014	1

'Commons Based Peer Production and agrarian knowledge systems: the case of Generation Challenge Programme (GCP)'	77th Annual Meeting Rural Sociological Society, Louisiana, USA	2014	1
'An alternative imagination to study commons: beyond state and beyond scientific establishment'	2nd International Conference on Knowledge Commons for sustainable Agricultural Innovations, Maringá, Brazil.	2014	1
'Understanding the efforts of Generation Challenge Programme (GCP) from commons perspective'	15th Biennial Global Conference International Association for the Study of the Commons, Edmonton, Canada	2015	1
C) Career related competences/personal development			
Interpersonal communication for PhD students	WGS, WUR	2012	0.6
Mobilising your scientific network	WGS, WUR	2012	1
Visiting research scholar	University of Wisconsin-Madison, USA	2013	4
Total			**34.9**

*One credit according to ECTS is on average equivalent to 28 hours of study load

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