

RIS A Think-Tank of Developing Countries

RIS is a New Delhi-based autonomous policy think-tank supported by the Government of India and devoted to trade and development issues. Its work programme focuses on policy research and capacity building in multilateral trade and financial negotiations, regional economic cooperation in Asia, South-South cooperation, new technologies and development, and strategic policy responses of developing countries to globalisation, among other issues. The work of RIS is published in the form of research reports, books, discussion papers, policy briefs and journals.

RIS has networked effectively with other prominent policy think-tanks, government agencies, industry bodies and international organisations in Asia and other parts of the world for collaborative research and joint activities. It has a consultative status with UNCTAD, and has been accredited to the Summit Meetings of NAM and WTO Ministerial Conferences. It has conducted policy research and other activities in collaboration with other agencies, including UN-ESCAP, UNCTAD, UNU, Group of 77, SAARC Secretariat, Asian Development Bank (ADB), the World Bank, Commonwealth Secretariat and the South Centre.

For more information about RIS and its work programme, please visit its website: www.ris.org.in

— Policy research to shape the international development agenda



RIS
Research and Information System
for Developing Countries

Core IV-B, Fourth Floor
India Habitat Centre
Lodhi Road
New Delhi-110 003, India.
Ph: 91-11-2468 2177-80
Fax: 91-11-2468 2173-74-75
Email: publication@ris.org.in
Website: www.ris.org.in
Website: www.newasiaforum.org

Asian Biotechnology and Development Review

Asian Biotechnology and Development Review

Vol. 12 No. 1

March 2010

ISSN: 0972-7566

- **The Role of Agricultural Biotechnology Policies in Thailand's Economy**
Orachos Napasintuwong
- **Agricultural Research, Public-private Partnerships, and Risk Management: Evidence from the International Agricultural Research System**
David J. Spielman, Frank Hartwich and Klaus von Grebmer
- **Of Choices and Dilemmas: Bt Cotton and Self-Identified Organic Cotton Farmers in Gujarat**
Devparna Roy
- **Patenting Status of Bioremediation Technologies in United States, Europe and India: A Comparative Study**
Neelima Jerath and Deepali

MARCH 2010



RIS
Research and Information System
for Developing Countries

Asian Biotechnology and Development Review

Editors

Biswajit Dhar, Director-General, Research and Information System (RIS)
Sachin Chaturvedi, Senior Fellow, Research and Information System (RIS)

Managing Editor

K. Ravi Srinivas, Associate Fellow, Research and Information System (RIS)

Editorial Board

S R Rao	Adviser, Department of Biotechnology (DBT), Government of India
Balakrishna Pisupati	United Nations Environmental Programme, Nairobi, Kenya.
Nares Damrogchai	Policy Researcher, APEC Centre for Technology Foresight, Thailand
Reynaldo V. Eborá	Executive Director, Philippine Council for Advanced Science and Technology Research and Development (PCASTRD), The Philippines
Bambang Purwantaram	Director, Southeast Asian Regional Centre for Tropical Biology, Indonesia
Sudip K. Rakshit	Vice President, Asian Institute of Technology (AIT), Thailand
Halla Thorsteinsdóttir	Assistant Professor, University of Toronto, Canada.
Dongsoon Lim	Dong-EUI University, College of Commerce and Economics, Korea
Ajay Parida	Programme Director-Biotechnology, M S Swaminathan Research Foundation, Chennai
Vibha Dhawan	Vice-Chancellor, TERI School of Advanced Studies, New Delhi

Editorial Advisory Board

M S Swaminathan	Chairman, M S Swaminathan Research Foundation, Chennai
William G. Padolina	Deputy Director General, International Rice Research Institute (IRRI), Manila, Philippines
Jikun Huang	Professor and Director, Centre for Chinese Agricultural Policy (CCAP), China
Govindan Parayil	Vice-Rector, United Nations University, Director, UNU-Institute of Advanced Studies, Japan.
V. S. Chauhan	Director, International Centre for Genetic Engineering and Biotechnology (ICGEB)

The editorial correspondence should be addressed to the Managing Editor, *Asian Biotechnology and Development Review*, Research and Information System for Developing Countries (RIS), Zone IV-B, Fourth Floor, India Habitat Centre, Lodi Road, New Delhi-110003, India. Telephones: 24682177-80. Fax: 91-11-24682173-74. E.mail: ravisrinivas@ris.org.in Website: <http://www.ris.org.in/abdr.html>

Copyright RIS, 2010.

RNI Registration No. DELENG/2002/8824

Printed by: D.K. Fine Art Press (P) Ltd.

The views expressed in the *Asian Biotechnology and Development Review* are those of the authors and not necessarily those of the RIS or the organisations they belong to.

This journal is abstracted in *Cab International and Science of Science*, of Council for Scientific and Industrial Research (CSIR), New Delhi.

Guidelines for Contributors

1. Submissions can be sent by email as an attachment preferably in MS-Word to the Managing Editor, ravisrinivas@ris.org.in. It is not necessary to send hard copies separately when the article has been sent by email. All submissions will be acknowledged on receipt. If the article cannot be sent by email for any reason then a hard copy of the article and a CD containing the identical text in MS-WORD format can be sent to Managing Editor: *Asian Biotechnology and Development Review*, Research and Information System for Developing Countries (RIS), Zone IV-B, Fourth Floor, India Habitat Centre, Lodhi Road, New Delhi 110003, India. (Tel. 00-91-11-24682177-2180, Fax: 00-91-11-24682173/2174). Manuscripts sent by post/courier with the text in CD should be typed on A4 paper on one side only, double space throughout and with ample margin on all four sides
2. ABDR is multi disciplinary journal. Please explain technical details in simple words for the benefit of non-technical readers.
3. Use 'z' in '-ize' '-ization' words; e.g., 'civilize', 'organization'. Use British spellings rather than American spellings. Thus, 'labour' not 'labor'.
4. Use figures (rather than words) for quantities and exact measurements including percentages (2 per cent, 3 km, 36 years old). In general descriptions, numbers below 10 should be spelt out in words. Use thousands, millions, billions, not lakhs and crores. Use fuller forms for numbers and dates— e.g., 1980-88, pp. 200-202 and pp. 178-84.
5. Specific dates should be cited in the form June 2, 2004. Decades may be referred to as 'the eighties'. Spell out 'the twentieth century', etc.

References: A list of references cited in the article and prepared as per the style specified below should be appended at the end of the article. Reference must be typed in double space, and should be arranged in alphabetical order by the surname of the first author. In case more than one work by the same author(s) is cited, then arrange them chronologically by year of publication.

All references should be embedded in the text in the anthropological style – for example '(Hirschman 1961)' or '(Lakshman 1989:125)' (Note: Page numbers in the text are necessary only if the cited portion is a direct quote)

Citation should be first alphabetical and then chronological – for example 'Rao 1999a, 1999b'. More than one reference of the same date for one author should be cited as 'Shand 1999a, 1999b'.

The following example illustrate the detailed style of referencing:

- (a) **Books:**
Hirschman, A. O. 1961. *Strategy of Economic Development*. New Haven: Yale University Press.
- (b) **Edited volumes:**
Shand, Ric (ed.). 1999. *Economic Liberalization in South Asia*. Delhi: Macmillan.
- (c) **Articles from edited volumes:**
Lakshman, W. D. 1989. "Lineages of Dependent Development: From State Control to the Open Economy in Sri Lanka," in Ponna Wignaraja and Akmal Hussain (eds): *The Challenge in South Asia: Development, Democracy and Regional Cooperation*. pp. 105-63. New Delhi: Sage.
- (d) **Articles from Journals:**
Rao, M.G., K. P. Kalirajan and R. T. Shand. 1999. "Convergence of Income across Indian States: A Divergent View". *Economic and Political Weekly*, 34(13): 769-78.
- (e) **Unpublished Work:**
Sande, H. 1995. "Innovations in Production". Unpublished Ph.D thesis. Amsterdam: Free University.

Asian
Biotechnology
and
Development Review

Asian Biotechnology and Development Review

Vol. 12 No. 1

March 2010

ISSN: 0972-7566

Contents

The Role of Agricultural Biotechnology Policies in Thailand's Economy.....	1
<i>Orachos Napasintuwong</i>	
Agricultural Research, Public-private Partnerships, and Risk Management:.....	21
Evidence from the International Agricultural Research System	
<i>David J. Spielman, Frank Hartwich and Klaus von Grebmer</i>	
Of Choices and Dilemmas: Bt Cotton and Self-Identified	51
Organic Cotton Farmers in Gujarat	
<i>Devparna Roy</i>	
Patenting Status of Bioremediation Technologies in United States,	81
Europe and India: A Comparative Study	
<i>Neelima Jerath and Deepali</i>	
Book Review.....	97



The Role of Agricultural Biotechnology Policies in Thailand's Economy

Orachos Napasintuwong*

Abstract: Agricultural biotechnology plays a major role in agricultural development in several countries around the world. At the same time, many countries are opposing to the technology while some others are considering the coexistence of dual markets. Thailand is among agricultural-based countries facing challenges in climate change, rising global competition, and shortage of energy supply. Biotechnology could be an alternative to solve these problems, but the national policies are still ambiguous. This article reviews biotechnology-related policies and regulations in Thailand, and their implications for agricultural development from an economic perspective.

Keywords: Agricultural Biotechnology, National Biotechnology Plans, Government R&D, GM products, trade policies, Thailand.

Introduction

Thailand is one of the first countries in Asia to recognize potential benefits and importance of agricultural biotechnology. The National Center for Genetic Engineering and Biotechnology (NCGEB) which was inaugurated in 1983, later became one of the National Science and Technology Development Agency (NSTDA) centers and is today known as BIOTEC. The main objective of BIOTEC is to support development and adoption of biotechnology. Plant Genetic Engineering at Kasetsart University and Microbial Genetic Engineering Unit at Mahidol University were two public universities that initiated research on biotechnology as early as 1985. A decade later, the first field trial of GM crops was granted to Flavr Savr tomato in 1994, followed by Bt cotton in 1996. During the time, successful transgenic crops, such as GM papaya in 1995, were developed by Thai scientists; however no GM crops have been approved for commercialization. The hurdle of agricultural biotechnology development in Thailand has been contributed partly by the halt of field trials of GM crops in April 2001 under a condition that the National Biosafety Law must be implemented. Even though the regulation was revoked on 25 December 2007, field trials of GM crops must be submitted to the government cabinet on a case-by-case basis, and the requirements are considered too restrictive.

* Department of Agricultural and Resource Economics, Faculty of Economics, Kasetsart University, Bangkok 10900, Thailand. Email: orachos.n@ku.ac.th

The social, economic, and political environment of the country influences how the technology is generated and disseminated. This article evaluates current biotechnology-related policies in Thailand and their implications for Thai economy.

Is Agricultural Biotechnology Relevant to Thai Economy?

Although the agricultural sector became less important to Thai economy as the country has undergone industrialization, a vast majority of population is still in agriculture. In 2007, the agricultural GDP accounted for 8.9 per cent of total GDP; however 40 per cent of the population was in agricultural sector, and 43 per cent of total labour force was agricultural labour in 2006 (Office of Agricultural Economics 2007a). In 2007, agricultural products generated 21.7 per cent of total export value. Among all agricultural export commodities, rubber products, rice, sugar and sugar products, tuna fish, frozen shrimps, chicken products, and cassava products have the highest export values (Office of Agricultural Economics 2007b). The agricultural land area accounts for almost 40 per cent of total land area, but the share has depreciated since the mid-1980s (Food and Agriculture Organization of the United Nations 2005). Given that agriculture remains an important sector, the productivity of important commodities in Thailand remains lower than other competing countries. For example, though one of the largest rice exporters, Thailand rice yield is among the lowest in Asia, and the productivity remains steady while most other Asian countries have continued to improve their rice productivity. To retain its competitiveness in world market, Thailand must continue to improve its agricultural productivity, and agricultural biotechnology could be one alternative. In addition, the increasing uncertainty in agricultural production from climate change and increasing demand for bio-fuel could create future food, feed, and fuel insecurity; it is hoped that agricultural biotechnology could also alleviate this problem.

Biotechnology-related Policies

In this section, policies are categorized into: 1) national biotechnology plans which include those stated in the national social and economic development plans and biotechnology policy framework, 2) government R&D, and 3) government resolution regulations which include bio-safety and field trial regulations, trade-related regulations, and GM-food labelling.

National Biotechnology Plans

There are two significant national policies related to biotechnology. One is the National Social and Economic Development Plan which indicates priorities for national development and biotechnology is considered an element of forces towards economic development during certain periods of time. The other is the National Biotechnology Policy Framework devoted purely to biotechnology policy.

National Social and Economic Development Plan (NSEDP)

NSEDP is the national roadmap developed by the Office of the Social and Economic Development Board. Each individual plans emphasize different key strategies for economic and social development during a five-year period. Biotechnology was incorporated in the plans in the mid-1980s, but was not always emphasized. The Science and Technology Development Plan was not included in the NSEDP until the 5th plan during 1982-1986 (Office of the Social and Economic Development Board 2008). The 6th NSEDP (1987-1991) gave emphasis to a special support of R&D in critical science and technology including genetic engineering and biotechnology. During the 7th NSEDP (1992-1996) genetic engineering and biotechnology were emphasized in agricultural development such as an improvement of production efficiency and a cost reduction by plant variety research. The biotechnology R&D became implicitly emphasized in the 8th NSEDP (1997-2001), as part of the integrated development by science and technology for sustainable growth. The 9th NSEDP (2002-2006) emphasized the R&D in biotechnology to improve agricultural productivity and self-reliance in production. Aiming to improve agricultural competitiveness, biotechnology research in developing and improving plant, animal, and aquaculture varieties was supported.

The current NSEDP (2007-2011) incorporates several issues related to biotechnology such as to emphasize the importance of biodiversity, to complete the biosafety law, to generate human capital in science and technology, and to clarify the position on future controversial policies such as GMOs.

National Biotechnology Policy Framework, 2004-2009

Recognizing that biotechnology could enhance economic development, in December 2003 the National Biotechnology Policy Committee was established and it resolved to endorse the Thailand's National Biotechnology Policy Framework (2004-2011). The framework was prepared by the Office of

the Social and Economic Development Board and the National Science and Technology Development Agency (NSTDA), and in 2005 it was shortened to six years to cover 2004-2009 to speed up the development process. The government, at the time, was committed to promote biotechnology development by investing over 5,000 million bahts in biotechnology R&D, and was also hoping for the emergence of more than one hundred new companies in the biotechnology business (National Center for Genetic Engineering and Biotechnology 2005).

Complying with government policy and the national agenda, the framework emphasizes on applying core technologies such as genomics, bioinformatics, plant and animal breeding by means of molecular markers to accelerate the development in agriculture/food, medical care, environment protection, new knowledge creation for the development of higher value-added products, knowledge-based policy, and strategic planning. In addition, the core technologies will promote biotechnology business, including high-end products and new types of services where modern biotechnology is required. Major goals of the National Biotechnology Policy Framework (National Center for Genetic Engineering and Biotechnology 2005) are as follows:

- To promote the emergence and development of new bio-business.
- To use biotechnology to promote Thailand as kitchen of the world.
- To symbolize Thailand as a healthy community and healthcare center of Asia.
- To utilize biotechnology for conserving the environment and producing clean energy.
- To stress biotechnology as a key factor for self-sufficient economy.
- To develop qualified human resource.

The strategic plan to achieve each goal in a particular year was also incorporated. To emphasize on the second goal which is to maintain and enhance national competitiveness in agricultural and food industries, the plan is to increase export value, improve the value of processed agricultural products. The key components of Thai strategies have following major features:

- To promote agricultural biotechnology research.
- To form clusters of high value-added manufacture in the supply chain such as shrimp industry, seed industry and important goods such as rice and cassava. Biotechnology is to be applied to increase

productivity, breed plans and livestock to suit the cultivating environment, reduce chemicals and raise quality to meet the changing market needs.

- To develop and use the potential of biotechnology for quick, precise, and specific detection and diagnosis in managing food, and seed safety by setting up a biotechnology laboratory to certify quality and standards for export products, and inspection of imported products.
- To emphasize on developing and producing new seed variety for exports.
- To expedite development of new lines of marine products to provide supplements and alternatives to existing products (shrimp).
- To develop technology and related business services in post-harvest and packaging technology to prolong shelf-life or agricultural products.
- To conduct research to collect scientific data needed in risk assessment of food and agricultural products for exports.
- To prepare and utilizing (scientific) data in decision-making, laying down key measures, and negotiating or solving trade barrier problems.

In addition, other goals related to agricultural development include:

- To produce energy from agricultural wastes, waste and wastewater from food/agriculture industries, including solid wastes.
- To utilize biotechnology in improving soil quality to raise the yield of agricultural products and reduce chemical usage.
- To develop technology for prevention, treatment, rehabilitation and recycling of materials for the environment, such as biodegradable food packing, to prepare for “green and clean” measures adopted by importers of Thai products.

Government R&D

Research Efforts by the Government

There are a number of government agencies supporting the development in the field of biotechnology. Prominent among them are National Center for Genetic Engineering and Biotechnology (BIOTEC) under NSTDA, Thailand Institute of Scientific and Technological Research (TISTR), Department of Agriculture under Ministry of Agriculture and Cooperatives, National Research Fund, National Research Council of Thailand, and

other public universities such as Kasetsart, Chulalongkorn, Chiangmai, and Mahidol.

BIOTEC is the main national biotechnology research institution. Its goal is to induce dynamics in research, development, and application of biotechnology in order to support technology development and adoption in both public and private institutions. This is achieved through establishing research programmes, including funding and programme management, as well as establishing research laboratories in collaboration with universities and government agencies. BIOTEC is both a granting agency and also a research unit. The center also engages in human resources development, management and technical services, technology investment, public awareness, information services and international cooperation (National Center for Genetic Engineering and Biotechnology 2008).

BIOTEC in collaboration with several other agencies has successfully developed new agricultural technology. Some recent development of transgenic plants includes yellow leaf curl virus-resistant tomato, ring spot virus-resistant papaya, vein-banding mottle virus-resistant pepper, salt- and drought-tolerant aromatic jasmine rice. Marker assisted selection (MAS) was also used in the breeding of rice and commercially important marine species such as black tiger shrimp (*P. monodon*). In addition, applications of modern biotechnology have been used at BIOTEC in the development of DNA probe for rapid detection of major shrimp pathogens such as white spot syndrome virus; the identification, mapping and utilization of rice blast resistance Quality Trait Locus (QTLs) to improve aromatic rice varieties; the development of protein enrichment of cassava waste for animal feed; and biological control of soil borne plant pathogen fungi (Tanticharoen 2004).

Table 1: Rice Yield (ton/hectare)

Country	Year					
	1961	1970	1980	1990	2000	2006
World	1.87	2.38	2.75	3.53	3.88	4.11
Asia	1.86	2.40	2.80	3.61	3.95	4.18
China	2.08	3.42	4.14	5.72	6.26	6.27
Japan	4.88	5.63	5.13	6.33	6.70	6.34
North Korea	4.31	4.39	4.07	3.00	3.16	4.25
South Korea	4.15	4.55	4.31	6.21	6.71	6.60
Cambodia	1.09	1.59	1.19	1.35	2.12	2.49
Indonesia	1.76	2.38	3.29	4.30	4.40	4.77

Table 1 continued

Table 1 continued

Laos	0.87	1.36	1.44	2.25	3.06	3.50
Malaysia	2.11	2.39	2.85	2.77	3.06	3.34
Myanmar	1.61	1.70	2.77	2.94	3.38	3.50
Philippines	1.23	1.75	2.21	2.98	3.07	3.68
Thailand	1.66	2.02	1.89	1.96	2.61	2.91
Vietnam	1.90	2.15	2.08	3.18	4.24	4.89
Bangladesh	1.70	1.69	2.02	2.57	3.48	3.90
India	1.54	1.68	2.00	2.61	2.85	3.12
Nepal	1.94	1.95	1.93	2.41	2.70	2.72
Pakistan	1.39	2.19	2.42	2.32	3.03	3.16
Sri Lanka	1.86	2.25	2.59	3.06	3.44	3.71

Source: International Rice Research Institute, 2008.

Biotechnology Human Capital Development

Although the development of GM crops has some limitations due to regulations during R&D process, Thailand has always recognized the importance of human capital development. Yet the investment is comparatively small. The education in biotechnology has been supported in three major ways: 1) Minister of Science, Technology, and Environment granted "Scholarships from Office of the Civil Service" for higher education abroad in demanded fields. During 1990-1996 over 300 scholarships in biotechnology were granted (Sriwatanapongse *et al.*, 2003), 2) BIOTEC and Thailand Research Fund provide scholarships for college education in biotechnology in Thailand, and 3) Center for Agricultural Biotechnology (CAB), established by five major universities and hosted by Kasetsart University, provides graduate study and research in agricultural biotechnology since 1999. The objectives of CAB are to enhance post-graduate study and to promote collaborative research in agricultural biotechnology. The establishment was initially supported by Asian Development Bank through the Higher Education Development Project.

The study by BIOTEC (2006) found that Thailand has a low capacity in producing master's and Ph.D. graduates in science and technology, including agricultural biotechnology. Table 2 shows the proportion of biotechnology graduates. In 2005, Thailand could produce about 100 Ph.D. students, 460 master's students, and 1,200 bachelor's students in biotechnology who were accounted for about 13 per cent, 4 per cent, and 1 per cent of science and technology students whereas the demand for human capital in biotechnology was estimated to be approximately 300 Ph.Ds, 600 master's, and 2,400 bachelor's graduates according to the National Biotechnology Policy Framework (National Center for Genetic Engineering and Biotechnology 2006).

Table 2: New Students in Science and Technology, 2003-2005 Academic

	Major	All fields (A)	Year			(B)/ (S&T)	(S&T)/ (A)	(B)/ (A)
			Science and Technology (S&T)	Biotechnology and related fields (B)				
2003	Bachelor	398,872	105,706	1035	1.0%	27%	0.3%	
	Master	38,380	9,762	349	3.6%	25%	0.9%	
	Ph.D.	1,965	1,329	79	5.9%	68%	4.0%	
2004	Bachelor	450,861	65,209	990	1.5%	14%	0.2%	
	Master	42,609	6,884	428	6.2%	16%	1.0%	
	Ph.D.	3,849	2,836	100	3.5%	74%	2.6%	
2005	Bachelor	409,284	113,371	1195	1.1%	28%	0.3%	
	Master	47,209	11,314	468	4.1%	24%	1.0%	
	Ph.D.	1,955	899	113	12.6%	46%	5.8%	

Source: National Center for Genetic Engineering and Biotechnology, 2006.

Intellectual Property Rights

Thailand provides two types of patents: inventions and designs. Although bilateral agreements exist, Thailand is not signatory to any international convention on patent protections. With respect to living organisms, Thailand's patent laws does not protect a number of fields of technology, animal, plant, and extracted substances from animals or plants. It presumably includes microbes and any components thereof which exist non-naturally (Ryan and Garduno 2004). This may imply disincentive, particularly for private R&D investment in biotechnology, as non-naturally occurring life forms are essential for modern biotechnology development.

Regulations from Government Resolutions

Biosafety

In 1990, the ad hoc bio-safety subcommittee was established under BIOTEC to develop and prepare appropriate and practical bio-safety guidelines in genetic engineering and biotechnology. The subcommittee completed the first draft of National Biosafety Guidelines in Genetic Engineering and Biotechnology for laboratory work and for Field Work and Planned Release in June 1992, before signing the Convention on Biological Diversity (CBD) at the Earth Summit. However, the ratification to CBD did not occur until January 2004. In 1993, the guidelines were approved for voluntary implementation and the National Biosafety Committee (NBC) was established with BIOTEC as secretariat. The Institutional Biosafety Committees (IBCs) were established at various research institutes, including

government agencies, universities, and private industry dealing with biotechnology. Their roles are to regulate the experiments on modern biotechnology or genetic engineering.

The guidelines were not statutory or promulgated into the law; therefore, neither the adoption nor the enforcement was mandatory or enforced. In the meantime, the first field trial of GM crops in Thailand was granted to Calgene Flavr Savr tomato on seed production, designed for only exports, as early as 1994. Subsequently, the field trial of Bt cotton was granted to Monsanto in 1996. Due to widespread contamination of Bt cotton from the trial fields before commercial production was permitted, on 3 April 2001, the Assembly of the Poor (AOP) filed a petition to the government to discontinue all field trials of GM crops until the National Biosafety Law is enacted. In response, the government halted Ministry of Agriculture's large scale field trials. In 2001, NBC revised the two National Biosafety Guidelines drafted in 1992 and added additional guidelines for the field trials of transgenic plants. As a result, the Biosafety Guidelines Related to Modern Biotechnology and Genetic Engineering of 2004 were recommended for use by the Department of Agriculture (DOA), and the Guidelines in Safety Assessment of Genetically Modified Foods were recommended for use by all concerned (Napompeth 2002).

The NBC and its secretariat were then transferred to Thailand Biodiversity Center (TBC) and began to draft the National Biosafety Framework (NBF) in 2001 with the support from UNEP-GEF. The Steering and Advisory Working Group on the Development of the National Biosafety Frameworks of Thailand was appointed on 2 November 2005 to complete NBF by the end of 2006, but was extended until the end of 2007. Because Thailand ratified the CBD in January 2004, it was deprived the eligibility to sign the Cartagena Protocol prior to that, and just became a party to the protocol in February 2006. In January 2008, the draft of NBF was approved, the evaluation process was started in April 2008 and it was expected to complete by 2009.

Plant Quarantine Act 1964 and Plant Variety Protection 1999

In 1999, the amendment of the 1964 Plant Quarantine Act strengthened the regulation to include all possible genetically modified plant varieties. On 17 March 2000, 40 plant species known to undergo genetic transformation were prohibited to be imported into and transported across the country, except for R&D. On 14 October 2003, an additional 49 transgenic varieties were listed as prohibited items for imports except for processed products.

There was no regulation on GMOs intended for direct use as food or feed, or for processing (GMO-FFPs), especially GM soybeans and maize. However, their products are subject to labelling requirements. Imports of GM livestock and aquatic animals must also be complied with the Department of Livestock Development and the Department of Fisheries regulations, accordingly, and considered by their respective institutional biosafety committees.

Prohibited Items for Production, Imports and Sales

The Ministry of Public Health announced in January 2001 (amended in June 2001) that foods containing Cry 9C DNA sequence or protein from genetic modification food items on the list are not authorized to produce, import, or sell. The examples of items on the list include popcorn, baby corn, Taco shell, corn chips/corn snack, corn flake, corn meal, corn flour, cream corn style, and frozen corn on the cob. The imported item must be certified that it does not contain Cry 9C DNA sequence or protein from genetically modified items or StarLink corn or other GMO.

GM Food Labelling

The Minister of Public Health's announcement in 2002 of the GM food labelling regulation requires that foods containing ingredients derived from GM soybean (and its products) and maize (and its products) in the top three components by weight, representing more than 5 per cent of the total weight, and having more than 5 per cent GM of each ingredient must be labelled. The list of regulated food containing DNA or protein from genetic modification in the ministerial announcement includes 22 items such as tofu, soy milk, natto, miso, canned soybean, frozen corn, corn starch and popcorn. The message on the label must be obvious and must state "genetically modified" or "produced from genetically modified ingredient". However, the message on the label must not give a misleading information by stating "not genetically modified food", "GMO-free", "does not contain genetically modified food" or "have isolated GM ingredient out". The regulation does not cover foods directly sold by small vendors who could provide information to the consumers. The enforcement started in May 2003.

In brief, Thailand does not permit the imports of listed 89 GM products except for R&D. There is no regulation on GM products intended for direct use as food or feed, or for processing, including GM soybeans and maize. The regulations by the DOA are for imports only, but regulations on GM

products developed domestically are not stringent and are on voluntary basis, except for food labelling requirement. Currently biosafety law is unexecuted, and field trials are limited to government fields and are subject to permission by the government cabinet.

Implications of Biotechnology-related Policies for the Economy

Very few studies have been done on the economic aspects of biotechnology policies in Thailand. This section will summarize few evidences to illustrate this issue.

Much of the debate on GM food production is on consumer acceptance. Several surveys had tried to assess consumers knowledge and their acceptance on GM food products. Thai topic (2004) conducted a survey of over 2,400 samples in six provinces including Bangkok. The results showed that among several criteria, consumers gave less importance to GM food than chemical residuals, freshness, cleanliness, and price when making purchasing decision. A similar result was also revealed for processed products that most consumers gave more importance to cleanliness and expiration date than GM product. The survey also found that only 17 per cent of the samples showed a complete understanding of GM technology while the majority had some understanding. Consumers who have higher education had a better knowledge of GM technology. However, the survey revealed that most consumers supported the R&D of non-food GM crops such as color-enhanced flowers and vaccine and medicine plants. Ph.D. graduates strongly agreed on GM food labelling whereas, consumers having lower than college degree did not, and the rest were neutral.

The same survey also showed that consumers were concerned about foreign and domestic market acceptance and the impacts on health and environment. Most consumers did not support the importation of GM products, including GM seeds. The lack of knowledge and understanding of GM technology, followed by lack of scientific evidences and clear government policies, contributed to most concerns over the development of biotechnology whereas monopolistic power in the seed industry was among the least concerns.

Chongvorakitwatna (2005) also found that from 167 consumers, 76 per cent of them knew GM crops. About 50 per cent of them were not sure about the dangers of GM products while 28 per cent believed that there were risks, and only 11 per cent said there was none. Sixty-six per cent of consumers thought that Thailand was not ready for GMOs in agriculture due to the lack of information and the lax of government policies. Nevertheless,

more than half of consumers were neutral toward the opposition of GMOs by the NGOs while 18 per cent supported the opposition of NGOs and 22 per cent did not.

Farmers' Perceptions

Thai topic (2004) found that farmers gave more importance to the productivity and price than whether it is a GM crop when making a production decision. From Jongvorakitwatna survey (2005), 73 per cent of 67 farmers who grew rice, cassava, beans, maize and vegetables knew GM crops. Forty nine per cent of farmers were not sure about the dangers of GM products while 32 per cent believed that there were risks, and only 18 per cent said there was none. Sixty five per cent of farmers were not sure if GM technology would benefit the country. Forty eight per cent of farmers opposed the production of GM crops, about 15 per cent of them supported it and 37 per cent were indecisive. Farmers also suggested that the government should evaluate the technology and reveal the information before promoting GM crop production.

Thai organic trade association (TOTA) representing organic farmers strongly opposed field trials and production of GM crops. In contrast, Kalaitzandonakes *et al.* (2007) conducted an *ex-ante* survey from 1,000 maize producers in 26 provinces during 2005-06 and found that the adoption of roundup-ready (RR) maize was (seed) price elastic. In other words, 61 per cent of farmers would adopt RR maize at 110 baht/kg, but dropped to 36 per cent if the price increased to 150 baht/kg. Other factors that differentiated adopters from non adopters included risk considerations on environment and health as well as personal propensity to innovate.

Implications from Consumers and Producers' Perceptions

Even though farmers and consumers acceptance of GM crops are varied by their knowledge, information, awareness and perceived benefits, there will be those who gain and those who lose from introducing GM technology. Considering product information on GM foods, current labelling regulation suggests that consumers who do not accept GM products will be able to differentiate between GM products from the non-GM ones, and may offer higher price for the non-GM products. However, a 5 per cent presence level may not be adequate for those who do not tolerate any contamination of GM ingredient while the cost of segregating and testing GM ingredients already incurred to producers. Few products in the market are currently labelled with "containing GM ingredient". It is possible that the regulatory

authorities are stringent on product inspection or products in fact do not meet the labelling requirements.

Most consumers may not understand the meaning of GMOs so even if it is labelled, it could be misleading. On the other hand, labelling regulation does not allow negative labelling such as GM-free. Several soybean products in the market such as soymilk and tofu portray misleading information for "GM-free". Even though it is against the regulation, no enforcement has been taken. As a result, consumers who are willing to pay more for non-GM products may not find the products they desired even though paying less whereas those who are indifferent between GM and non-GM products will have to pay more and thus increase transaction cost.

Economic Impacts of GM Crop Adoption

Economy impacts of GM crop adoption must be evaluated on a case-by-case basis and should be taken into account in order to suggest appropriate technology. Bt cotton was one of the first GM crops being introduced in Thailand. The Center for Applied Economic Research at Kasetsart University (2000) has estimated the economic impacts of Bt cotton in Thailand. The results show that by comparing Bt cotton with the SR 60 (the local variety resistant to leaf roll virus (LRV), but not to bollworm), Bt cotton generated higher yield than SR 60, except in areas with heavy spread of LRV disease. It was suggested that Bt resistance trait must incorporate LRV resistance to ensure the benefits. The French Centre de cooperation Internationale en Recherche Agronomique pour le Development (CIRAD), working with Kasetsart University, transferred Bt resistance gene to SR 60, but the project has been suspended, in part due to regulatory difficulties.

The study summarizes overall benefits of Bt cotton in Thailand. These include: 1) a direct benefit to farmers from cost reduction and yield improvement even when seed cost is higher, 2) a trade balance improvement since Thailand is a net importer of cotton and 3) an employment creation in ginning business which eventually will generate national income.

US Department of Agriculture (2005) analyzed the benefits of PRSV resistant GM papaya in Thailand. Papaya is an important crop for domestic consumption, both green and ripe, but the infestation of PRSV is one of the most important production problems which destroy a large production area. The study was based on the yield improvement assumption from 2.79 tons/rai of the local variety to 42 tons/rai of GM papaya estimated by DOA. Farmer's gross income would increase dramatically although it

may vary by locations, planting technique and type of fruit (green or ripe) at the time of sales.

Both studies show direct benefits of GM crop adoption at the farm-level. Napasintuwong and Traxler (2007) also found similar results of GM papaya and Bt cotton adoption using economic surplus model. Although this study made assumptions based on scientific evidences and economic environment, other assumptions such as adoption rate were not directly from the farm survey. All the studies found positive results from GM crop adoption, ignoring the potential cost of losing foreign markets, and potential negative impacts on environment and health. In the case of papaya, Napasintuwong and Traxler (2009) analyzed that even if Thailand was to lose its papaya export market, the authorization of GM papaya would still benefit both consumers and producers.

Direct benefits from GM crop adoption to farmer's income are evident from the yield improvement and cost reduction from several studies. Given that the intellectual property right protection in Thailand remains low and the government support from public research still provides cost benefit for farmers, the economic benefits of GM crop adoption seem obvious. However, the impact remains unclear if Thailand was to lose its export market among major commodities (e.g. rice and shrimp). The direct benefit to Thai consumers has not been documented, but it is perceived that consumers could benefit from cheaper and better quality products.

Trade Policies

Current import regulations are more stringent on biosafety than on food safety. Thailand permits the imports of GM seeds only for scientific experiments, but allows the imports of GM soybeans and maize for food processing and feed consumption due to shortage of domestic supply. Most of maize grains are imported from Bangladesh, Gaum and Sri Lanka; maize seeds are mostly imported from India, Indonesia, and Vietnam. These exporting countries are not known to produce GM maize so there is a small impact of GM technology from maize imports. The supply of soybeans, however, increasingly depends on its imports.

The proportion of GM soybean imports is increasing while the domestic supply is decreasing. The majority of import grains is used for soybean oil industry; some is used in feed industry, and the rest is used in food processing. In 2004, more than 85 per cent of total supply was imported, mainly from the US and Argentina where Roundup Ready

soybeans are commonly grown and 88 per cent of total imports were used for oil extract. Although Thailand still does not permit a commercial production of any GM crops, the contamination in food supply chain may come from import materials as shown in Table 3.

Table 3: Import Quantity of Contaminated GM Soybeans (tons)

Year	Industry using import GM soybeans			Total import quantity	Total import production	Domestic
	Oil extracts	Feed	Processing			
1990		0	0	0	0	573,827
1991		0	0	0	0	433,919
1992		158,029	0	0	158,029	425,208
1993		44,684	0	0	44,684	515,353
1994		97,989	0	0	97,989	523,467
1995		202,540	0	600	203,140	454,355
1996		397,064	19,696	2,028	418,788	365,528
1997		709,406	159,182	782	869,370	348,382
1998		654,394	32,369	481	687,244	319,077
1999		834,698	169,943	3,326	1,007,967	317,284
2000		1,030,451	249,161	10,710	1,290,322	312,608
2001		1,027,029	325,666	10,497	1,363,192	279,326
2002		1,192,667	329,738	6,124	1,528,529	261,058
2003		1,149,636	533,253	6,759	1,689,648	236,194
2004		1,266,376	166,553	2,872	1,435,801	241,773

Source: Biosafety Clearing House of Thailand, 2008 cited Office of Agricultural Economics.

The study by Suzuki *et al.* (2004) analyzed the economic impacts of GM soybean imports using welfare economic model. The domestic soybean market was divided into two: one was GM-sensitive market (e.g. soymilk, soy sauce, tofu, and soybean products), and the other was GM-non-sensitive market (soybean oil, soybean meal, and feed). In the without-labelling scenario, the study showed that processors would benefit from lower price, but farmers would not be affected since there was no import of seeds. Due to soybean pledging policy, domestic price is higher than import price and the import quantity must be met with local supply. If the demand for GM-sensitive market decreases by 20-25 per cent, the economic surplus of this market would decrease and resulted in a total economic loss. However, if the demand in the GM-sensitive market does not change, there would be a total benefit to the country. In the GM-testing and labelling scenario, if the demand for GM-sensitive products does not change from the labelling requirement, an increasing cost would not be compensated by any benefit. If, however, the segregation creates a higher demand for GM-

sensitive market, the net benefit would increase. To sum, in the identity preservation scenario and no import scenario, the cost of GM soybean imports would be much higher than the cost under current regulation, but it would require testing standards and trustworthy organizations to certify the products.

Agricultural products contribute to a large share of exports. Current export regulations on GM products (certification and labelling) are subject to the importing countries requirement. Some export markets are stringent on GM products such as the EU, Japan, and Korea. The agreement on Sanitary and Phytosanitary Measures (SPS) and Technical Barriers to Trade Agreement of the WTO may be used against Thai exports. Take, for example, the case of trade barrier against canned tuna fish in vegetable oil imposed by Egypt, though the case was eventually dropped due to untraceable GM materials. Consequently, the segregation and certification of GM ingredients in the coexisting markets must be carefully organized in order not to lose major export markets. This implies increasing cost of production.

Regarding the rice market, on 16 November 2006 the Rice Exporters Association of Thailand and the Vietnam Food Association signed a joint agreement on no-GM rice production and exports (Greenpeace 2006). This shows that both major rice exporters are still fear losing their export markets if GM rice is mixed with normal rice in the supply chain.

If the large trade partners such as the US were to enforce WTO SPS standards, Thailand could potentially face trade dispute. Policies to prohibit GM crops production and importation of GM seeds for commercial production and the labelling regulation for GM food may not be sufficient to use against the imports of GM commodities. As Tantivasadakarn (2006) suggested, Thailand should use the Cartagena protocol to negotiate for the imports of GM crops by using the impacts on social and economic environment as an argument. The benefits of protecting biodiversity and conserving local varieties may also be used against GM imports since the intellectual property rights in several western countries do not protect the rights for the conservation of natural or local traits by seed selection of local communities. Before commercializing GM commodities, Thailand should develop intellectual property system to protect the market from trade partners.

For certain sensitive food market, technical trade barriers against GM commodities may be used against exports from Thailand. Thailand

has to be able to manage the coexisting markets prior to commercializing GM commodities; otherwise, the loss of export markets could generate large negative impacts. Managing coexisting markets implies higher transaction cost, and total economic impacts must be taken into account to properly evaluate the commercialization of GM crops

Conclusions

Facing the challenge of with productivity improvement to remain competitive in producing high quality products, Thailand is in the dilemma between promoting agricultural biotechnology and strengthening conventional practice to conserve local genetic resources. The development policy for agricultural biotechnology is promising, but the regulatory process does not support it in practice. While national policies emphasize biotechnology as a key factor to promote economic development, the regulation of GM products is the contradictory. The prohibition of GM crops importation, field trials and commercial production has slowed down the R&D while soft intellectual property rights protection has also contributed to the discouragement. Thai consumers and producers are neither knowledgeable nor much aware of the technology. Therefore, the information coming from the public media can easily give the wrong impression. In addition, the fear of losing foreign markets contributes to greater concerns. Nevertheless, a shortage of supply resulted in unavoidable permission of some GM imports such as soybeans and maize. Biotechnology should be considered as an alternative for productivity improvement of certain crops, particularly feed and energy crops where demand is expected to be increasingly high whereas the application for major export crops may have to be evaluated more carefully. Positive economic impacts in several other countries suggest that biotechnology should not be ignored as it may be a potential solution for agricultural development, but the implications for Thailand have to be adjusted based on social, economic, political environment.

References

- Biosafety Clearing House of Thailand. 2008. Imports and Usage of Transgenic Agricultural Products Situation in Thailand. Available on the World Wide <http://bch-thai.onep.go.th>. (in Thai)
- Center for Applied Economic Research. 2000. *Bt Cotton: Benefits to the Economy*. Bangkok: Faculty of Economics, Kasetsart University.
- Chongvorakitwatana, S. 2005. "GMOs and Thai Agriculture (Attitudes of agricultural GMOs Stakeholders)". Bangkok: Office of Agricultural Economics. Available on the World Wide Web

- http://www.oae.go.th/download/article/article_20090225110659.pdf. (in Thai)
- Damrongchai, N. 2003. "Agricultural Biotechnology in Thailand". *Asian Biotechnology and Development Review*, 5(1): 23-38.
- Food and Agriculture Organization of the United Nations. 2005. Land Statistics [database]. Available on the World Wide Web <http://faostat.fao.org>.
- Greenpeace. 2006. "Greenpeace Appraises Thai-Vietnam Agreement on Non-GMO Rice". Available on the World Wide Web <http://www.greenpeace.org/seasia/th/news/756938?mode=send>. (in Thai)
- International Rice Research Institute. 2008. World Rice Statistics [database]. Available on the World Wide Web <http://www.irri.org/science/ricestat/index.asp>.
- Kalaizandonakes, N., P. Suntornpithug, and S. Thongrag. 2007. The Potential Adoption of Roundup Ready Maize in Thailand: Economic and Institutional Drivers. Unpublished Report. Economics and Management of Agrobiotechnology Center, University of Missouri-Columbia and Prince Songkla University. (in Thai)
- Napasintuwong, O. and G. J. Traxler. 2007. "Ex-ante Economic Evaluation of Transgenic Plants Adoption in Thailand". *Kasetsart University Journal of Economics*. 14(2): 86-102. (in Thai).
- Napasintuwong, O. and G. Traxler. 2009. "Ex-ante Impact Assessment of GM Papaya Adoption in Thailand". *AgBioForum*. 12(2): 209-217. Available on the World Wide Web <http://agbioforum.org/v12n2/v12n2a05-napasintuwong.htm>.
- Napompeth B. and C. Kongsawat. 2002. "National Biosafety Frameworks (NBFs) in Thailand". Paper presented at the International Workshop on Impacts and Biosafety of Genetically Modified Agricultural Product. Taipei, Taiwan, ROC. Sept. 9-12, 2002.
- National Center for Genetic Engineering and Biotechnology. 2005. *Thailand National Biotechnology Policy Framework, 2004-2009*. 2nd edition. Pathumthani: National Science and Technology Development Agency. Available on the World Wide Web <http://biotec.or.th/document/W-Eng/FrameWork9-11-2548.pdf>.
- National Center for Genetic Engineering and Biotechnology. 2006. *Human Development for Future Biotechnology Development in Thailand: under National Biotechnology Development Policy Framework, 2004-2009*. Pathumthani: National Science and Technology Development Agency.
- National Center for Genetic Engineering and Biotechnology. 2008. *Biotec in Brief*. Available on the World Wide Web <http://biotec.or.th/>.
- Office of Agricultural Economics. 2007a. *Thailand Agricultural Economic Indicators. Agricultural Statistics Report No. 412*. Bangkok: Center for Agricultural Information. (in Thai).
- Office of Agricultural Economics. 2007b. *Thailand Agricultural Trade Statistics*. Agricultural Statistics Report No. 412. Bangkok: Center for Agricultural Information. (in Thai).
- Office of the Social and Economic Development Board. 2008. 5th – 10th National Social and Economic Development Plan. Available on the World Wide Web <http://www.nesdb.go.th/>. (in Thai).
- Ryan, M. P., and E. Garduno. 2004. *An Intellectual Property Ssystem in Thailand for Bbio-innovation and Commercialization: A National Strategy for Business, Government, and the Technology Community*. Washington, DC: International Intellectual Property Institute. Available on the World Wide Web http://www.iipi.org/reports/Thailand_Report.pdf.
- Sriwatanapongse, S. et al. 2003. Situations and Scenarios of Agricultural Biotechnology, the Roles of Biotechnology to Thai Agriculture: Achieving the Goals. Report submitted to project committee of the master plan, situations, scenarios, and roadmap of Thailand agricultural biotechnology development. (in Thai).
- Suzuki, P., C. Tantivasadakarn, and W. Sithithaworn. 2004. Economic Impact Assessment of GM Soybeans Importation for Consumption and Processing. Report submitted to National Center for Genetic Engineering and Biotechnology. Bangkok: Faculty of Economics, Thammasat University. (in Thai)

- Tanticharoen, M., R. Valyasevi, J. Donovanik, and T. Thanapaisal. 2003. "Recent Major Developments of Biotechnology in Thailand". Paper distributed at the Consultative Meeting of Asia Cooperation Dialogue in Biotechnology. New Delhi, India. 6-7 October 2003.
- Tanticharoen, M. 2004. Research and Development on Agricultural Biotechnology in Thailand. Bangkok: National Center for Genetic Engineering and Biotechnology.
- Tantivasadakarn, C. 2006. Environmental and Trade Regulations of GMOs: Analytical Issues and Implications. Report submitted to The Thailand research Fund. (in Thai)
- Thai topic. 2004. Awareness, Understanding, and Acceptance of Transgenic Plants and Animals. Report submitted to National Center for Genetic Engineering and Biotechnology. (in Thai)
- US Department of Agriculture. 2005. *A Study on the Economic Benefits of Biotechnology Papaya in Thailand*. Bangkok: Foreign Agriculture Service.



Agricultural Research, Public-private Partnerships, and Risk Management: Evidence from the International Agricultural Research System

David J. Spielman*
Frank Hartwich**
Klaus von Grebmer***

Abstract: This article examines how public-private partnerships (PPPs) address the risks associated with agricultural research—particularly those associated with biotechnology research—conducted for the benefit of small-scale farmers in developing countries. The article specifically examines how PPPs manage and mitigate risks arising from market, institutional and systemic weaknesses that often hinder pro-poor innovation in developing-country agriculture. Data are drawn from a survey of 75 projects undertaken by the Consultative Group on International Agricultural Research (CGIAR) and its private sector partners. Findings indicate that while PPPs are improving how the international system manages its research agenda, they are fraught with risks for both public and private sector partners. Precautionary, legal, and financial strategies to manage risk are needed, as are effective communications strategies, platform-building strategies, and foresight into worst-case scenarios. However, evidence suggests that such strategies are not commonly used or available to the international research community and its partners, especially in the field of biotechnology research.

Keywords: Public-private partnership, agricultural research and development, innovation incentives, risk management, biotechnology

Introduction

The changing nature of science and technology in developing-country agriculture necessitates new approaches to conducting research. Public-private partnerships in agricultural research are viewed by some in the research for development community as a way of addressing this need for change by offering alternative means of conducting advanced research, commercializing new technologies, and deploying new products. This is

* International Food Policy Research Institute, Addis Ababa, Ethiopia.
Email: d.spielman@cgiar.org (corresponding author).

** International Food Policy Research Institute, San José, Costa Rica.

*** International Food Policy Research Institute, Washington, D.C., USA.

particularly relevant with respect to research that aims to benefit small-scale, resource-poor farmers in developing countries, and leverage advanced science to address their problems. The purpose of this article is to examine how PPPs manage and mitigate risks that result from the market, institutional, and systemic failures that hinder innovation in developing-country agriculture, with particular reference to agricultural biotechnology (agbiotech).

Public-private partnerships (PPPs) are commonly defined as collaborations between public and private sector entities in which partners jointly plan and execute activities to accomplish agreed-upon objectives while sharing the costs, risks and benefits incurred in the process. Although the topic is one of increasingly popular inquiry, there are few studies on the risks associated with PPPs in developing-country agriculture, or potential mechanisms to address such risks. This article attempts to fill this gap by identifying and illustrating the different types of risk inherent in PPPs and PPPs involving agbiotech research, and the mechanisms that might be used to manage or mitigate them.

This is an important strategic issue for the Consultative Group on International Agricultural Research (CGIAR),¹ arguably the organization best placed to bridge the gap between cutting-edge technological advances in research conducted in industrialized countries, and applications thereof to agriculture in developing countries (see Spielman 2007; World Bank 2004).² It is also an important issue for corporate leaders in the agricultural sector who hold the key to many of the new tools and materials of agbiotech and genetic modification (GM). Thus, this article examines 75 partnership-based projects undertaken by the research centres and programs of the CGIAR, and identified through a study carried out in 2007 (see Spielman, Hartwich, and Von Grebmer 2007).

The article proceeds as follows. Next section develops a conceptual framework that defines and describes PPPs in agricultural research, followed by a review of previous studies on PPPs in developing-country agriculture in the following Section. Section 4 details the methods and data used in this paper, followed by a discussion of results and findings in Section 5. Concluding remarks are offered in the last Section 6.

Markets, Institutions, and Systems: A Conceptual Framework

In the field of science and technology, PPPs are commonly viewed as a means of increasing sectoral competitiveness and promoting innovation by combining resources from the public and private sectors to realize synergies in the conduct of research (Reid *et al.*, 2001; von Hippel 1988;

Doz 1996). They are being used with some success in the field of health and medicine to tackle both global and local challenges (see, for example, Buse and Walt 2000a, 2000b).

With reference to developing-country agriculture, PPPs are also seen as a way of strengthening public research systems by providing access to cutting-edge research tools, materials and proprietary knowledge; skills needed to carry products through regulatory processes; and the know-how associated with product development, deployment and marketing (Spielman and Von Grebmer 2006; Pingali and Traxler 2002; Pray 2001). These types of PPPs are expected to provide reciprocal benefits to the private sector by increasing access to new or emerging markets in developing countries, locally-specific scientific expertise and plant genetic materials, and opportunities to strengthen reputational integrity (Hall 2005; Reinhardt 2004; Byerlee and Fischer 2002).

Hence, public-private partnerships are a topic of interest to analysts in a variety of disciplines, including economics, public administration, and management science. Drawing on work by Horton, Prain, and Thiele (2009), Hall (2006), Hall *et al.* (2003), Hagedoorn *et al.* (2000), the study of PPPs can be classified into four categories, as follows.

- Neoclassical economics and industrial organization approaches that focus on analyzing the economics of inherent failures in the market for scientific and technological knowledge;
- transaction cost theory approaches that address the implicit costs of producing and exchanging knowledge under different institutional regimes and organizational structures;
- strategic management approaches that examine how firms compete, network, or collude in an effort to accumulate and deploy resources and capabilities to strengthen their market positions; and
- innovation systems approaches that examine how collaborations between public and private agents are conditioned by internal behavior, practices and routines and by the external social and economic context within which they operate.

This article offers a conceptual framework that begins with the basic economics underlying PPPs and then integrates transaction cost theory, followed by strategic management and innovation systems approaches. To do so, the article begins by looking at PPPs as knowledge production processes.

Specifically, consider PPPs as one among several means of organizing the production of some output - in this case, knowledge and technology. Knowledge production is constrained by the costs of capital and labour, a standard economic description of any production process. However, knowledge production is also subject to several unique impediments which can be described here in terms of market, institutional, and systemic failures.

Market failures occur when the social benefits of production exceed the private benefits, resulting in chronic under-provision by the private sector and the need for public intervention. Many knowledge production processes fall into this category, particularly those for which the outputs are public goods;³ or are consumed by individuals who have a limited willingness to pay, limited market access, or limited purchasing power (Dalrymple 2006; Martin and Scott 2000).

A classic example of market failure in agricultural research is found in developing-country markets for improved planting materials for “orphan” crops of marginal commercial value such as sorghum, millet, groundnut, pigeonpea, cassava, or sweet potato (Tripp 2000; Herdt 2001). Where farmers can replant saved seed and capture the gains conferred by research and where private firms cannot prevent them from doing so through legal or technological means, the profit-maximizing private firm will optimally choose not to invest in research, thus creating a chronic undersupply of improved seed (see Evenson and Kislev 1973; Pray and Fuglie 2001). This necessitates public-sector intervention in the market, typically through the financing and management of plant breeding programmes.

Institutional failures occur where the socio-economic institutions -for example, regulatory systems, commonly-accepted practices, or social norms - needed to govern knowledge exchanges do not exist or do not perform effectively. In these circumstances, knowledge exchanges may incur transaction costs above and beyond the actual outlays and opportunity costs associated with the exchange, a characteristic of exchanges first described by Williamson (1975, 1985, 1991). This implies that agents engaged in the process of knowledge exchanges must invest in mechanisms to monitor and enforce their exchanges, thus making their transactions more costly than would otherwise be the case, and thus inhibiting knowledge production.

Returning to our earlier example, one might consider intellectual property rights (IPRs) (e.g., patents and plant variety protection certificates) as institutions developed to reward innovators for their successful investments in cultivar improvements, thereby reducing transaction costs associated with contested claims over the rights to innovation

rents while simultaneously incentivizing innovative behavior. Similarly, quality assurance systems for planting materials (e.g., seed certification or truth-in-labelling) might be considered institutions designed to address information asymmetries resulting from the inability of farmers to make *ex ante* assessments of seed quality when such information known only by the seller (Tripp and Louwaars 1997; Gisselquist and van der Meer 2001; Tripp 2001). And where legal institutions are insufficient to facilitate knowledge exchanges, other organizational mechanisms may emerge. Examples include vertical integration of an agricultural supply chain by a single company, or contractual integration of farmers, gin owners, and cropsistence firms engaged in the deployment of genetically-modified insect-resistant cotton cultivars, as was the case in Mexico (Smale *et al.* 2009; Traxler and Godoy-Avila 2004; Traxler *et al.*, 2003).

Systemic failures result from an inability of agents engaged in the knowledge production process to learn about each other, identify areas of complementarity and synergy, build and sustain trust through interpersonal or organizational relationships, communicate and exchange ideas effectively, or respond to leadership. This also impedes processes of knowledge exchanges and can further exacerbate knowledge production. For example, while the transfer of a transgenic construct from a private firm to a public research organization may provide scientists with an important tool to further their research in plant varietal improvement, a simple contractual exchange fails to bring with it several implicit elements. This might include assurances to the firm that the construct will be carefully stewarded to prevent misuse or abuse; an understanding that the construct will be used for the public good rather than private benefit; or an unwritten agreement the construct will be used in conjunction with exchanges of the tacit knowledge relating to its effective application (see Spielman and Von Grebmer 2006).

PPPs are organizational arrangements that aim at simultaneously addressing market, institutional and systemic constraints. They bring public research organizations into the knowledge production process when the incentives to private investment are insufficient. They create contractual obligations among knowledge production agents that delineate how costs, risks, and benefits are shared, particularly where formal laws and regulations in developing countries to govern such exchanges are insufficiently robust. And they provide a platform for the exchange of knowledge that may combine explicit/codified technical information with more implicit/tacit, complex, or context-specific information.

However, the relative benefits of a PPP over alternative arrangements must also be considered against the coordination costs associated with organizing, executing and sustaining the PPP. Coordination costs are typically incurred by efforts undertaken to ensure the sustained commitment and participation of parties to a PPP, and to prevent free-riding, whereby partners minimize their contribution to a PPP relative to their expected benefits. Commitment mechanisms incur costs associated with allocating time and effort to strengthening trust, awareness and leadership; conducting repeated interactions among partners; or monitoring other partners' contributions.

Such issues suggest the need to dig deeper into the underlying nature of coordination among heterogeneous innovation agents. A systems perspective addresses this need by providing a more nuanced understanding of agents' routines, behaviours, and practices; the nature of their actions and interactions; and the dynamics of their learning and change processes (Nelson and Winter 1982; Lundvall 1988; Metcalfe 1988). Relatedly, a strategic management perspective offers insights into how both public and private agents identify, manage, or mitigate risks associated with multi-agent innovation processes. Thus, by combining these two approaches, this article examines the extent to which PPPs overcome the market, institutional, and systemic failures by facilitating interactions and learning that can potentially lead to synergistic innovation processes, while also addressing the inherent or perceived risks in these processes. This is particularly relevant to PPPs in the area of agricultural biotechnology, as will be discussed later.

Partnerships in Agricultural Research

This article expands on the conventional definition of PPPs set forth earlier to capture the richness of experience gained from other types of interactions between the public and private sectors in the CGIAR. Hence, PPPs are herein defined as any type of formal or informal arrangement between public and private sector entities to conduct research.⁴ Such PPPs exist in industrialized countries to conduct and commercialize agricultural research. Models include cooperative research and development agreements (CRADAs), used in the United States to finance the movement of public research into commercial applications (Link 2002); and university-industry relationships (UIRs) to support public research with commercial potential in fields such as agbiotech (Ervin *et al.*, 2003). The CRADA model has been particularly useful in moving agricultural technologies from state and federal research programmes to seed companies and other private firms

in the United States (Parker *et al.*, 2001; Day-Rubenstein and Fuglie 2000; Fuglie and Schimmelpfennig 2000).

However, in the context of developing-country agriculture, PPPs are possibly more popular in the development community's rhetoric than in practice (see, for example, WEF 2005; USAID 2004; DFID 2003; EC 2003). While this popularity may stem from the many conceptual advantages described earlier, it is also driven by the reality that growth in public expenditure on agricultural research is stagnating in many developing countries. Although countries such as China, India, and Brazil stand out as leaders in terms of public expenditure on agricultural research, many other developing countries are characterized by slowing or declining growth trends. This is the case across much of Sub-Saharan Africa, where agricultural research has a vital role to play in improving the economic prospects for the region's many countries that are largely reliant on agriculture (Pardey *et al.*, 2006; Beintema and Stads 2006).

The popularity of PPPs is also driven by the long-term decline in, and disillusionment with, foreign assistance for agricultural research (Byerlee 1998). Although a significant portion of this decline has been reversed over the past five years with new donor commitments to new funding vehicles and programmes, the long-term effects of a 15 year decline in research funding are not insignificant to the quality of research infrastructure and scientific personnel in many developing countries (Pardey *et al.*, 2006).

Finally, the popularity of PPPs may also be driven by the growth of private investment in agricultural R&D, itself driven by rapid growth in global market opportunities, progress in the commercialization of agbiotech, and stronger regulatory regimes that favour private investment in research (Naseem *et al.*, 2010; Pray 2002; Pray and Fuglie 2001). However, there is limited evidence to suggest that much of this investment is targeting more than a few developing countries with advanced research capabilities, large markets, and strong regulatory regimes (Spielman 2007).

Thus, most studies on PPPs in developing-country agriculture focus on the cutting edge of agricultural research: agbiotech and the ways in which proprietary knowledge can be safely transferred from the private sector in support of public research and eventual commercialization of new crop technologies. See, for example, Pray (2001) on agbiotech PPPs in Brazil, China and India; Rausser (1999), Rausser *et al.* (2000), and Byerlee and Fischer (2002) on IPR management tools to facilitate technology transfers and manage risks in agbiotech PPPs; and Krattiger (2002) and Spielman *et al.* (2006) on regulatory regimes to accelerate the deployment of agbiotech through PPPs.

While the emphasis on cutting-edge science and technology is not necessarily misplaced, Chataway (2005), Hall (2006), and Hall (2005) suggest the need for more analysis of the organizational routines, behaviours, and practices that allow for more effective exploitation of the PPP approach. These studies argue that analyses of PPPs (whether in agbiotech or otherwise) should place greater emphasis on innovations at the institutional and organizational levels, and how these types of innovation influence the process of technological innovation. Their arguments suggest that the evolution of a PPP - the movement of partners and their projects through sequences of interactive learning cycles that allow for reevaluation and readjustment of a research collaboration - is as fundamental to the innovation process as scientific research on the technologies in question.

Several studies on PPPs in several CGIAR research centres lend weight to these arguments. Hall *et al.* (2003, 2002), Dar and Bantilan (2006), and Prasad (2006) examine PPP experiences at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) to describe how interactions between public and private researchers in PPPs have been critical to promoting innovation in the centre's organizational behaviours and practices. A study by Smith (2005) of the East Coast Fever (ECF) Vaccine project of the International Livestock Research Institute (ILRI) similarly describes how the collaborative, disembedded nature of a PPP helps to overcome organizational sclerosis and inward-looking tendencies of public research organizations, and how a market-oriented, results-based outlook drives partners to produce real outcomes.

Other studies on PPPs in the CGIAR focus on best practices. Such studies are often highly context-specific, but do shed light on governance, management and operating issues and solutions. See, for example, Patiño and Best (2002) on the Latin American and Caribbean Consortium to Support Cassava Research and Development (CLAYUCA) of the International Centre for Tropical Agriculture (CIAT); Binenbaum (2006) on the Latin American Fund for Irrigated Rice (FLAR) at CIAT; and Reddy *et al.* (2001) and Gowda *et al.* (2004) on the ICRISAT Hybrid Parents Research Consortia. Ayele *et al.* (2006) provides a closely related analysis of 12 partnership-based agbiotech projects in Kenya, five of which include CGIAR centres, and finds these partnerships tend to be small, donor-dependent and loosely coordinated; highly supply-driven rather than end-user oriented; and limited in scope with respect to their impact on agricultural innovation and poverty reduction.

Only a few studies consider these issues in the context of the wider CGIAR system. For example, Özgediz and Nambi (1999) highlight the importance of strategic fit and mutual trust among partners as a means of exploiting the CGIAR's natural role as knowledge brokers between public research organizations in the developing world and private (mainly crop-science) firms in the industrialized world. Binenbaum *et al.* (2001) hone in on the issue of strategic fit and honest brokerage by examining PPPs in the CGIAR with specific reference to exchanges of proprietary knowledge - both plant genetic materials held by the CGIAR in the public trust, and genetic constructs and tools owned by the private sector. Spielman and von Grebmer (2006) extend the analysis and find that PPPs in the CGIAR are constrained by mutually negative perceptions between the CGIAR and its private sector partners, the prohibitive costs of coordinating PPPs and risks associated with the use of proprietary knowledge.

Ironically, the considerable literature on PPPs in the CGIAR masks the fact that the private sector is a relatively small player in the CGIAR's wider research agenda and with respect to pro-poor research for developing-country agriculture. A study by the CGIAR Science Council Secretariat (2006) finds that the private sector represents only 6 per cent of the 3,395 organizations working in collaboration with the CGIAR, and just 4 per cent of the centres' "highly relevant" collaborations. Nonetheless, the continued growth of private investment in agricultural R&D, and the rapid development of new tools and technologies in the private sector, suggest that the CGIAR's partnerships with the private sector will remain a topic of importance well into the future.

Methods and Data

As a starting point for analysis of PPPs in the CGIAR, a rudimentary classification of partners and partnerships in the international agricultural research system was developed in a study by Spielman, Hartwich, and Von Grebmer (2007). The term "partners" encompasses those organizations described in Table 1. Note that the definition does not include farmers despite the fact that they are often considered "private" partners when their participation is critical to the conduct of research, such as in a participatory research project or in product testing. However, since farmers might also be defined as the beneficiaries, clients, or end-users of research outputs, the study chose to omit them from the definition of partners. However, farmer organizations and producer associations operating on a commercial

basis were included since they operate collectively as organizations not unlike a firm.

Table 1: A Classification of Public-private Partners in Agricultural Research

Classification	Type of organization	Example of organization
Private	Local firm (registered in a single developing country)	Western Seed Co. (Kenya)
	Foreign firm (registered or operating in a single industrialized country)	Li-Cor (United States)
	Regional firm (registered or operating in more than one developing country)	SeedCo (Zimbabwe)
	Multinational firm (registered or operating in multiple countries)	Monsanto (United States)
	Farmer or producer organization	La Federación de Productores de Arroz (Colombia)
	Industry association	Croplife International (Belgium); World Cocoa Federation (United States)
	Private research organization	Centro de Investigaciones en Palma de Aceite (Colombia)
Public	Charitable foundation	Monsanto Fund (United States); Barwale Foundation (India)
	National agricultural research organization	Kenyan Agricultural Research Institute (Kenya)
	International agricultural research centre	International Maize and Wheat Improvement Centre (CIMMYT); International Centre of Insect Physiology and Ecology (ICIPE)
	Public university	Huazhong Agricultural University (China)
	Advanced research institute	Institute for Genomic Research (United States)
Civil society	International/development organization	United Nations Development Program
	Nongovernmental organization	Save the Children (United States)
	Community-based organization	Local village organizations associations

Source: Authors, adapted from Spielman, Hartwich, and Von Grebmer (2007).

Philanthropic or charitable organizations pose a similar definitional problem. While their motives are often comparable to those of bilateral or multilateral donor organizations, they may also have close associations with their corporate parent that influence their activities. For the purposes of this article, charitable foundations are considered private sector partners where a corporate entity can be directly associated with the funding, governance and/or activities of the foundation. Thus, philanthropies such as the Rockefeller or Ford Foundations which have no relation to an identifiable corporate parent are not considered private sector partners, while the Barwale Foundation (a foundation associated with MAHYCO, an Indian seed company) or the Syngenta Foundation for Sustainable Agriculture (a foundation associated with Syngenta AG, a multinational crops science firm) are considered private sector partners.

In keeping with the wider definition of PPPs set forth above, the study developed five functional categories of PPPs that are listed below and described further in Table 2.

Table 2: A Typology of Public-private Partnership

Type of partnership	Role Private sector	Public sector	Civil society	Main risk bearer ^a	Hypothetical impact on agricultural innovation
Resourcing Contracting	Financing R&D	R&D Facilities, expertise, funding		Public Private	+ +
Commercialization	Product deployment	R&D	Product deployment, monitoring and evaluation	Private	+
Frontier research	R&D, financing	R&D, financing		Private, Public	+++
Sectoral/value- chain development	R&D, planning, financing, product deployment	R&D, planning, financing	Planning, financing, product deployment, monitoring and evaluation	Public, private, civil society	+++

^a A plus sign (+) indicates the hypothetical degree of positive impact that the public-private partnership may generate on the three goals identified in this study.

Source: Authors, adapted from Spielman, Hartwich, and Von Grebmer (2007).

1. Resourcing partnerships, where CGIAR centres or programmes receive funding from philanthropic foundations associated with private firms, or receive scientific expertise from private firms.
2. Contracting partnerships, where CGIAR centres' facilities or expertise are contracted to private firms, or where CGIAR centers or programmes contract private firms to conduct research.
3. Commercialization partnerships, where CGIAR centres or programmes transfer research findings and materials to private firms for commercialization, marketing, and distribution.
4. Frontier research partnerships, where CGIAR centers or programmes jointly undertake cutting-edge research activities characterized by some unknown probability of success.
5. Sector development partnerships, where CGIAR centres or programmes collaborate with networks of public, private, and civil society partners to develop a commodity subsector and/or its associated value chain.

The study then obtained data from three sources: PPP-related documents from CGIAR centres, programmes, and partners; semi-structured interviews with key informants engaged in purposively-selected PPP projects; and an email survey of CGIAR centres and programmes on their PPP projects. Key documents included materials obtained through personal communications or from the public domain, for example, project descriptions, evaluations, corporate publications, conference proceedings, press releases, and website information; as well as documents provided by centres and firms such as material transfer agreements, letters of agreement, terms of reference, business plans, commercialization agreements, financial reports, internal presentations, personal communications and partnership engagement policies. Additional documentation came from the proceedings of a 2005 conference on PPPs in international agricultural research (IFPRI, 2006).

Semi-structured interviews were carried out in relation to five purposively-selected CGIAR centres that were engaged in multiple PPPs as of early 2006. Within each centre, the study chose several focal PPPs to examine to ensure some degree of heterogeneity in terms of PPP type and the availability and accessibility of partners (Table 3).⁵ Key informants associated with the focal PPPs were drawn from among public sector, private sector and civil society partners, and were interviewed on

project objectives, partner goals, operations and management, interaction processes, organizational change, and poverty impacts (Table 4).

Table 3: Focal CGIAR Centres and Public–private Partnership Projects

Focal centre /location	Focal partnership ^a
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India	Agribusiness incubator and hybrid parent line consortia
International Centre for Tropical Agriculture (CIAT), Palmira, Colombia	CLAYUCA and rose powdery mildew research
International Livestock Research Institute (ILRI), Nairobi, Kenya	East Coast Fever Vaccine research International Maize and Wheat
Improvement Centre (CIMMYT), Nairobi, Kenya	Striga-resistant maize research

Source: Authors, adapted from Spielman, Hartwich, and Von Grebmer (2007).

Additional data on PPPs were gathered from an email survey sent to the director generals of the 15 centres in May 2006. A total of 12 out of 15 centres responded to the survey and follow-up queries that were focused on the purpose, partners, outcomes, duration, and budgets of centre PPPs.

Table 4: Semi-structured Interview Subjects, by Affiliation

Affiliation	Number of interviews
International agricultural research organizations	40
Private firms	21
Government agencies ^a	3
Nonprofit/nongovernmental organizations ^b	7
Charitable foundations and donor agencies	4
Total	75

^a “Government agencies” include national agricultural research organizations and ministries of agriculture.

^b “Nonprofit/nongovernmental organizations” include independent entities established to manage a public–private partnership, organizations engaged in international technology transfer activities, and conventionally defined nongovernmental or community-based organizations.

Source: Authors, adapted from Spielman, Hartwich, and Von Grebmer (2007).

Key Findings

Monogamy, Exclusivity and Other Findings

The study identified 75 PPPs in the CGIAR that were active in 2004 or later (Table 5). Of these 75 partnerships, 28 per cent exist for the purpose of sector development, followed by resourcing (23 per cent), contracting (21 per cent), commercialization (16 per cent) and frontier research (12 per cent).

Seven of these partnerships involve agbiotech, including applications such as: genetic modification; marker-assisted selection (MAS); new laboratory techniques for micro-propagating disease-free planting material; genome mapping and nucleotide sequencing; and bioinformatics. The seven agbiotech PPPs clustered around genetic modification to improve major cereal crops (rice, maize, and wheat), genomics, and bioinformatics. While these PPPs generally did not engage the private sector in orphan crop improvement through royalty-free licenses of genes to the private sector - an approach that is conventionally viewed as a key strategy in pro-poor PPPs - several projects did make use of such licensing arrangements, for example, the beta carotene-enhanced (“golden”) project with IRRI and other partners. Furthermore, these seven PPPs tended to be operating at relatively early research stages, indicating that it is too early to draw conclusions about their success, for example, whether they resulted in commercial applications, high adoption rates among farmers, or changes in farmers’ yields, costs, or income.

Table 5: Distribution of Public–private Partnerships in the CGIAR, by Centre since 2004

Centre	Number	Share of total
International Rice Research Institute (IRRI)	17	23
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	11	15
International Centre for Tropical Agriculture (CIAT)	10	13
International Maize and Wheat Improvement Centre (CIMMYT)	9	12
Bioversity International ^a	8	11
International Centre for Agricultural Research in the Dry Areas (ICARDA)	6	8
International Institute of Tropical Agriculture (IITA)	5	7
International Livestock Research Institute (ILRI)	4	5
International Water Management Institute (IWMI)	3	4
World Agroforestry Centre	3	4
International Potato Centre (CIP)	1	1
International Food Policy Research Centre (IFPRI)	1	1
Africa Rice Centre (WARDA)	1	1
WorldFish Centre	0	0
Centre for International Forestry Research (CIFOR)	0	0
Total	75	100

Notes: A total of 75 partnerships were identified through the survey and other sources; four of these are multicentre partnerships. CIFOR, IITA, and the World Agroforestry Centre did not provide survey responses. For CIFOR, information on public–private partnerships could not be obtained by any method; for IITA, information was obtained through document analysis; for the World Agroforestry Centre, information was obtained through document analysis and key informant interviews.

^a Formerly the International Plant Genetic Resources Institute (IPGRI).

Source: Authors, adapted from Spielman, Hartwich, and Von Grebmer (2007).

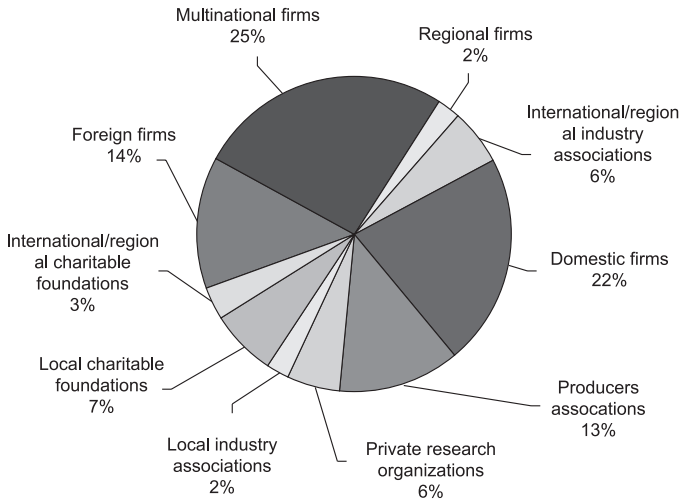
Approximately 43 of the partnerships (57 per cent) are collaborations that engage foreign private sector entities, a category that includes foreign (industrialized-country) firms, multinational firms, or international industry associations and charitable foundations. An equal number and proportion of partnerships are collaborations that include domestic entities, that is, developing-country firms, private research organizations, producer associations, and local industry associations and charitable foundations (Figure 1). The overlap between these two categories is relatively small: only four partnerships engage both foreign and domestic entities (5 per cent). Moreover, only 30 PPPs (40 per cent) engage additional public-sector partners, either foreign or domestic. Only 18 PPPs (24 per cent) engaged national agricultural research organizations in developing countries, organizations that represent the CGIAR's traditional partners.

A high proportion of PPPs in the CGIAR are exclusive collaborations (Table 6). A total of 45 partnerships (60 per cent of the total) involve exclusive relationships with the private sector that do not involve other public sector or civil society organizations. Further, 32 of these exclusive partnerships (43 per cent of the total) are also "monogamous," meaning they involve just one centre and one private-sector partner. Of these monogamous PPPs, 21 involve foreign entities (66 per cent), and of those, multinational firms accounted for slightly less than half (9 partnerships or 12 per cent of the total). The remaining 11 PPPs (34 per cent) are collaborations with domestic entities. Relatedly, exclusive PPPs with foreign entities tended to be smaller (three partners on average) than PPPs with domestic entities or a combination of foreign and domestic entities (six partners on average).

Project size as measured in terms of annual budget ranges from less than US\$5,000 to US\$923,000, with a mean budget of approximately US\$186,000, based on 45 PPPs for which financial information was provided. Extrapolating from the available data, PPPs represent just 4 per cent of the CGIAR's aggregate financing averaged over the period 2001-05 (Table 6).

Relatedly, the mean duration of a PPP in the CGIAR is approximately 4.2 years, ranging from several months to 12 years. In general, low-budget, short-term partnerships were resourcing PPPs such as scientific exchanges with the private sector conducted at the International Water Management Institute (IWMI). Big budget, long-term PPPs included both frontier research partnerships such as those hosted by the International Maize and Wheat Improvement Centre (CIMMYT) and the International Rice Research Institute (IRRI) that involve technology licensing agreements; and sector development partnerships managed as multistakeholder platforms, for example, CLAYUCA and FLAR at CIAT.

Figure 1: Private-sector Partners in the CGIAR System, by Type



Source: Authors, adapted from Spielman, Hartwich, and Von Grebmer (2007).

Table 6: An Overview of Public-private Partnerships in the CGIAR

Details of partnership	Statistics	
	Mean	Standard deviation
Budget and duration		
Total number of partnerships	75	—
Annual project budget (U.S. dollars) ^a	186,152	234,039
Project duration (years)	4.2	2.8
Private-sector partners per partnership ^b	1	4.6
Other partners per partnership ^{b,c}	0	2.7
Total partners per partnership ^b	2	5.6
Exclusivity and monogamy	Number	Percentage
Partnerships with foreign private-sector entities only	40	53
Partnerships with domestic private-sector entities only	31	41
Partnerships with both foreign and domestic entities	4	5
Partnerships with 1 private-sector partner only	45	60
Partnerships with 2–10 private-sector partners	27	36
Partnerships with more than 10 private-sector partners	4	5
Partnerships with multinational firms	23	31

Table 6 continued

Table 6 continued

Crop-science firms	15	65
Agri-food firms	6	26
Other firms	2	9
Partnerships with the public sector		
Partnerships with public-sector organizations	19	25
Partnerships in agricultural biotechnology	14	
Agbiotech partnerships with multinational firms	7	

^a Budgets figures cited here refer to total project budgets as reported by the centres surveyed by this study, and refer to financial (but not in-kind) contributions. Financing sources may include donor agencies, private foundations, and other sources of funds.

^b Averages are given as median figures.

^c Includes public research organizations, public organizations, international organizations, international development organizations, advanced research institutes, nongovernmental organizations, community-based organizations, and public universities in both industrialized and developing countries (see Table 1).

Source: Authors, adapted from Spielman, Hartwich, and Von Grebmer (2007).

Knowledge Exchanges and Research Commercialization

Findings further suggest that PPPs in the CGIAR are concentrated in two main areas: (a) accessing resources, information, and technology from the private sector to further centre research and (b) commercializing technologies that are designed to improve crop productivity and post-harvest value addition. The former area of concentration is characterized by partnerships that revolve around fund-raising from private sector sources (for example, financial donations from private foundations) or transfers of privately-held IPR (for example, advanced genetic constructs or diagnostic tools) to support public research projects. The latter area is characterized by efforts to move publicly-held research outputs (for example, improved hybrid breeding lines) to the private sector for non-exclusive commercial use.

These findings suggest that PPPs are a mechanism with which to finance public research, access private sector assets, and move public research off the shelf and into the market. However, findings also suggest that few PPPs have explicit risk management strategies. This is true even with respect to the partnerships identified here that (a) involve researchers with technologies that are the subject of international debate and controversy, such as agbiotech and GM crops, and (b) involve public and private research organizations in the exchange and use of transgenic constructs and other proprietary technologies that may be susceptible to misuse or abuse by partners or third parties. This is also true for the 23 partnerships that involve public research organizations with multinational corporations whose presence in the international development agenda

is the subject of international debate and controversy, particularly with respect to the seven partnerships where agbiotech is also involved. These issues are examined in detail below.

Risk and Sources of Risk

Research projects, whether conducted in the public or private sector, often involve a degree of risk, both real and perceived. Covariate risks, for example, emerge from the wider social and political environment in which research is conducted, or beneficiaries and end-users are targeted, or the economic and financial climate in which research investments are made. Thus, the heated global discourse over GM crops, for example, poses risks for many of the CGIAR's PPPs that deal in agbiotech research.

More relevant is the issue of idiosyncratic risks - risks associated with the probability that the research process will not yield a successful output or product, will yield a success along a time horizon that is too long for continued investment, or will yield a product that cannot pass through legal and regulatory hurdles associated with moving from proof of concept to commercial deployment. Necessarily, these types of risks are part of the culture underlying research and are often justified by the potential returns to a successful research process.

In addition to these commonly known risks are several types of idiosyncratic risks are unique to PPPs. They include the risks associated with weak financial infrastructure, coordination among diverse partners, and exchanges of proprietary knowledge assets. These are discussed in detail below.

Financial Risk and Risk Transfer Mechanisms

Research that is characterized by some uncertain outcome requires a means of sharing or transferring risk from those who are least able to those who are most able to bear it. Both the formal financial sector and the government play a role in transferring risk by financing private research either through private investment (for example, venture capital) or through public expenditures (for example, programmes designed to commercialize research).

Often, such formal private financing and public-sector programmes are weak - if not nonexistent - in the agricultural research sector in developing countries. For example, domestic seed firms that invest in breeding programmes may have limited access to financial markets or public programmes (relative, say, to firms in the manufacturing or service sectors) and thus limited means to transfer the risks of a breeding project to others.

Consider, for example, the Western Seed Company, a small firm in Kenya with in-house breeding capacity that plays an active role in several PPPs with CIMMYT, such as the Striga-Resistant Maize and Quality Protein Maize projects. The firm's participation in these projects is partly or wholly financed by the firm's own resources and includes testing, releasing, and producing breeder seed. As a small firm in a competitive market where formal financing for seed firms is uncommon, the Western Seed Company assumes an extensive level of risk by engaging in these PPPs. In the absence of formal (private or public) mechanisms to transfer risk, the Western Seed Company must fully absorb the risks posed by difficult regulatory barriers, adverse climatic shocks and other vagaries that affect the seed business. These types of risk are of considerable importance to smaller domestic firms partnering with the CGIAR.

Risk and Coordination

The failure to sustain commitment between partners - whether through formal mechanisms, such as contract adherence and execution, or informal commitment mechanisms, such as trust-building activities and communication - is another major risk facing PPPs in the CGIAR.

Consider, for example, the Drought Tolerant Crop Initiative, a PPP-based platform organized to develop and deliver new technological innovations to drought-prone, food-insecure farmers in developing countries. Despite the platform's strong focus on product development and deployment, the initial interest of key players in both the public and the private sectors and some well-planned efforts to launch the initiative, evidence suggests that the PPP failed to take off in its initial stages (see Doering, 2005a,b,c).

What went wrong? Published proceedings of discussions among key parties suggest that stumbling blocks included distrust of private-sector motivations and incentives, recognition that regulatory regimes and market infrastructure in many countries were insufficiently developed to attract private participation in the delivery of end-products to smallholders, and concerns over the specific technologies under consideration. But possibly the most important stumbling block was the lack of resources - in terms of people, time, money, and energy - needed to organize and coordinate the initiative. Here, as in many PPPs, coordination costs and system-level failure contributed significantly to the probability of success.

Risk and Knowledge Assets

Risk issues in CGIAR partnerships often relate to the exchange and use of improved germplasm, hybrid parent lines, transgenic constructs, and other such assets held by centres or their private partners. For the centre, the issue of risk is often associated with attempts by private firms to assert control over assets held in trust for the public good. For the multinational firm, the issue of risk is more about the transfer and use of IPR to the public sector and the possibility that materials and technologies may fall into the hands of competitors or parties who might misuse or abuse the materials and technologies. This can potentially damage the firm's reputation or brand, incur legal or criminal liability for the firm, and do harm to the firm's public-sector and civil society partners as well.

Consider, for instance, CIMMYT's project on Insect-Resistant Maize for Africa (IRMA). The project aims to introduce pest resistance traits conferred by *Bacillus thuringiensis* (Bt) into maize varieties and hybrids commonly cultivated in East Africa. While the Syngenta Foundation for Sustainable Agriculture provided considerable funding for the project's initial research phases, the project made use of a Bt event available in the public domain - in this case, an event from a Canadian university. The choice to use a public event rather than one developed or owned by the foundation's parent company, Syngenta, reduces the exposure of public-sector partners to reputational risk resulting from possible associations with corporate interests being drawn by third-party observers. It also reduces the risks associated with a worst-case scenario in which misuse of the event would be directly linked back to the corporate parent.

But even the best-laid plans for mitigating risk can fail, as experiences from this same project illustrate. In August 2005, a technician at the Kenya Institute of Agricultural Research accidentally treated a test plot containing Bt maize with pesticide, thus ruining the experiment. Press reports followed soon after with allegations from the chair of Kenya's National Biosafety Committee that the project had succumbed to pressure from international organizations to sidestep regulatory procedures (see, for example, Sunday Nation 2005). While the allegations proved to be untrue, the project partners' slow response to the public and political damage caused by press reports suggests that the absence of an effective communications (and damage control) strategy was a setback for the project.

To be fair, CIMMYT's experience is not unique in the CGIAR. The global discourse surrounding such controversial topics as agbiotech and GM crops has exposed centres and their partners to multiple risks, primarily

with regard to safe stewardship and reputational integrity. For example, the negative attention generated by anti-GM watchdog organizations over the CGIAR's PPPs with leading crop-science firms such as Monsanto, Bayer Crop-Science, and Syngenta can cloud the CGIAR's reputational integrity as a key player in the agricultural research for development community - so much so that the CGIAR's own NGO Partnership Committee disengaged from the system in 2002.⁶

Risk Management and Mitigation Tools

This is not to say that risks make the PPP approach undesirable. Rather, centres need to have effective risk assessment, management and mitigation strategies in place to safeguard their research, financing and reputational integrity should a worst-case scenario materialize. Risk management and mitigation strategies for both individual partners and the PPP as a whole are discussed below.

Precautionary Strategies

The default strategy for the CGIAR is one of caution: transfer materials to traditional public-sector partners only and minimize contact and exchanges with the private sector. However, this strategy may be difficult to sustain in light of centres' commitments to the Food and Agriculture Organization of the United Nations (FAO) and the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), which stipulate that materials held in the public trust will be made available to both public and private parties.

The default strategy for the private sector - particularly foreign entities such as multinational firms - is similarly cautious. Many firms choose to disengage from the development-through-partnership agenda and limit their interactions with centres, or they only share technologies and materials of relatively low commercial value or that pose relatively low risk should they fall into the hands of competitors or be misuse by third parties. However, this precautionary strategy may also limit the ability of such firms to gain access to emerging markets in developing countries, breeding materials from centres, or other valuable information or assets. In the case of CIMMYT's Insect-Resistant Maize for Africa project, for example, application of the precautionary strategy was implicit in the decision to use a transgenic event available in the public domain. However, several respondents noted that this choice may have also affected the pace of R&D under the project.

Legal and Contractual Strategies

Legal and contractual strategies offer the next-best option to risk management. Such strategies are common in PPPs where the operative relationship is based on technology licensing and material transfers or requires strong measures to ensure safe stewardship of proprietary technologies and materials. In these types of partnerships, explicit contractual agreements formalize the roles and relationships among parties; ensure that parties jointly plan and execute activities to accomplish agreed objectives; and distribute costs, risks, and benefits equitably. Provisions such as indemnifications and warranty disclaimers may be included to provide partial protection to the licensor or seller or a technology from the actions of the licensee or buyer.

The recent creation of organizations designed to facilitate legal and contractual agreements in partnership-based research projects illustrates this strategy. The African Agricultural Technology Foundation, for example, is mandated to facilitate the transfer of technologies (including, but not limited to, advanced biotechnologies) between research organizations in the public and private sectors. In doing so, AATF provides the expertise - individuals with significant experience in agricultural science, communications, legal affairs, and regulatory affairs - needed to design and negotiate formal agreements that address the risks associated with PPPs.

Still, it is important to recognize that regardless of how skilled organizations such as AATF are at mitigating risk through legal recourse, or how well the centres' own legal capabilities are developed, they are still likely to be limited relative to those of the multinational firms with which they partner. Thus, several respondents argued the need to bolster legal expertise at the system- or centre-level sufficiently for the CGIAR to confidentially navigate protracted litigation or negotiate with batteries of lawyers from the private sector. Most others, however, felt that legal recourse offered little benefit to any of the parties to a partnership: rather, they argued that legal recourse would only lead to costly litigation and the loss of good faith among partners, thus harming project implementation and the long-term growth of public-private partnerships. Moreover, many argued that legal recourse is difficult to pursue in developing countries, where legal and regulatory regimes are rarely equipped to address the complex issues underlying PPPs and technology development.

Yet there is some evidence to suggest that the legal context within which the CGIAR operates is changing, thus necessitating greater legal expertise in centres and the system. New regimes governing IPR exchange, biosafety regulation, and agricultural trade are emerging in many developing countries where the CGIAR conducts research, while some centres are finding themselves more exposed to host-country regulations that govern R&D than in past decades. This changing context has led ICRISAT, for example, to establish a separate entity - the Technology Innovation Centre (TIC), a US – registered foundation operating in India - to commercialize new technologies with the private sector and absorb some of the associated risks (see TIC 2005).

Financial Strategies

Missing in many PPP projects are financial strategies to transfer the risks borne by small domestic firms, as described above. Financial mechanisms, such as commercial loan guarantees from public sector partners, small grants administered through competitive schemes, or credit programmes managed by charitable foundations could play a role in mitigating some of these risks. Several programmes along these lines are being developed (for instance, under the Forum for Agricultural Research in Africa [FARA]), but it remains to be seen whether the programmes will be open to small firms, entrepreneurs, and other private-sector actors operating in markets where the formal financial infrastructure needed to transfer and share risk remains weak or nonexistent.

Communications Strategies

Formal risk management strategies, such as those described above, are only as strong as the communications strategies behind them. Communications strategies are designed to manage and mitigate risk through efforts that include building social and political support for a given PPP, educating end-users on proper product stewardship practices, informing beneficiaries and observers of the potential benefits of the PPP through appropriate media channels and preparing provisions to mitigate damage caused by worst-case scenarios.

Illustrative of a proactive risk-management strategy is ICRISAT's efforts to mainstream its Agri-Science Park (of which the Agri-Business Incubator is a part) into Andhra Pradesh's wider "Genome Valley" initiative. ICRISAT's strategic efforts to gain political endorsement and support from the government as part of the state's own strategic initiative in research

and innovation can potentially insulate the centre from political risk, even in the volatile environment of state-level politics in India.

Platform-building Strategies

A critical risk-management strategy for the successful PPP - like any investment project - is proper design and funding. This often requires that the PPP be established on a solid platform that allows the relevant parties to come to agreement on a common objective and to commit resources to achieve that objective. The platform may be an informal coalition of organizations, a coalition headed and managed by a lead organization, or a legal entity established to manage the project with some degree of decisionmaking independence from the partners themselves.

Elements of a successful platform include clear definition of the problem, its solution and the resources needed to achieve the solution; establishment of benchmarks to gauge progress and decide on next steps; and effective communication channels to all key stakeholders through which to exchange knowledge, resolve conflicts and change course as needed. While many PPPs in the CGIAR attempt to build such platforms, findings suggest that the absence of a solid platform, as illustrated earlier with the Drought-Tolerant Crop Initiative, is the single-most important determinant of success.

The importance of platform-building is also seen in the case in CIAT, which operates a separate PPP unit designed to catalyze partnerships by assisting in the promotion of collaborative undertakings, identification of common interests, and design of the organizational structure. The unit's main functions include identifying possible business opportunities and partners, organizing roundtables and conferences where potential partners are brought together on topics of mutual interest, and providing advisory services on organizational design to deal with PPP governance, management, and administration issues.

In summary, PPPs are fraught with risk for centres and their private-sector partners. Precautionary, legal and financial provisions are needed, as are effective communications platform-building strategies, PPP management units and foresight into the worst-case scenario. By and large, these strategies are not commonly used or available to PPPs in the CGIAR.

Conclusions

The findings presented above suggest that public-private partnerships in the international agricultural research system are serving a wide variety of

objectives ranging from research to designed to increase food security by increasing yield and output, to new areas such as post-harvest value addition and value chain development. Findings further suggest that few of these partnerships incorporate risk management strategies to address worst-case scenarios, even in cases where technologies and partners are potentially controversial, as is sometimes the case with agbiotech research.

These findings attempt to close the gap between the popular rhetoric in support of PPPs and the need for more rigorous analysis. However, findings also suggest the need for further study of PPPs in agricultural research and their impact. First, further analysis is needed to better understand the incentive structures that encourage or discourage international research centres to partner with the private sector and whether changes in the mandates, organizational structures, and funding of the international research system will affect these incentives. Second, analysis is also needed on the impact of these PPPs on innovation, risk management, research efficiency and the livelihoods of their ultimate beneficiaries, especially given that so few have achieved on-the-ground results to date. Third, further insight is needed in the lessons being learned from parallel investments in PPPs on health, environment, and other fields of development. These analyses and insights are particularly important to furthering pro-poor agbiotech research, where PPPs are potentially critical to synergizing public and private assets to promote agricultural development, economic growth and poverty reduction in developing countries.

These recommendations should be viewed as a necessity in light of the high expectations of the development community on the one hand, and the low level of interest and effort among key partners on the other. These realities suggest a real risk that policymakers, research managers, and private-sector leaders will become dissatisfied with the PPP approach. Such dissatisfaction would be detrimental to the agricultural research and the development of new agricultural technologies. What is needed, then, is greater financial and intellectual investment in harvesting the potential of PPPs and transforming them into tools that support developing-country agriculture.

Acknowledgments: The authors thank Joachim von Braun, Andrew Bennett, Beatriz Avalos Sartorio, Robert Chapman, Hugo de Groote, and Javier Ekboir for their knowledge and insights; Joanna Chataway, Nicholas Linacre, Selçuk Özgediz, Saleem Esmail, Clare Narrod, Maria Ines Mendoza, Victoria Henson-Apollonio, and two anonymous reviewers for their constructive comments; and Martha Negash, Wondimsiamregn Mekasha, Etenesh Yitna, Elizabeth Carbone, and Mary Jane Banks for their technical assistance. The authors also express their appreciation to colleagues in the public, private, and civil

society sectors who facilitated visits from the project team, shared their knowledge and expertise in interviews, and responded to surveys and follow-up inquiries. This study was conducted with generous support from the Syngenta Foundation for Sustainable Development and the U.K. Department for International Development. Any and all errors are the sole responsibility of the authors.

Endnotes

- ¹ The CGIAR is a nonprofit alliance of countries, international and regional organizations, and private foundations established in 1971 to mobilize agricultural science to reduce poverty, foster well being, promote agricultural growth, and protect the environment. The CGIAR supports 15 international centers that work with national research systems, civil society, and the private sector to achieve these goals. See www.cgiar.org.
- ² The priorities of the CGIAR system are: (1) sustaining biodiversity for current and future generations; (2) producing more and better food at lower cost through genetic improvements; (3) reducing rural poverty through agricultural diversification and emerging opportunities for high-value commodities and products; (4) promoting poverty alleviation and sustainable management of water, land, and forest resources; and (5) improving policies and facilitating institutional innovation to support sustainable reduction of poverty and hunger (CGIAR 2006).
- ³ A public good is commonly defined in the economics literature as a good that is non-excludable (an individual or firm cannot be effectively excluded from using the good) and non-rival (the consumption of the good by one individual or firm does not reduce availability of the good for consumption by others).
- ⁴ See Linder (1999), Hagedoorn *et al.* (2000), and Schaeffer and Loveridge (2002) for more nuanced definitions.
- ⁵ Additional PPPs were also covered in the interviews to obtain supplementary information on cross-cutting issues. However, the availability and accessibility of partners (particularly from the private sector) were more limited in these cases. These partnerships included the On-Farm Innovative Enterprises in Watershed Programme at ICRISAT, Allanblackia Development for Smallholder Cultivation at the World Agroforestry Centre, the Latin American Fund for Irrigated Rice at CIAT, and various commercialization activities at the International Centre of Insect Physiology and Ecology (ICIPE), a non-CGIAR center. The inclusion of ICIPE in this study provided insight into alternative partnership approaches taken by a research organization with a mission, mandate and programme bearing both similarities to and differences from those of the CGIAR centers.
- ⁶ See, for example, criticism of the CGIAR from GRAIN (2001) and deGrassi and Rosset (2003); and an account of the CGIAR NGO Partnership Committee's disengagement in NGOC (2002) and Bezanson, Narain, and Prante (2004).

References

- Ayele, S., J. Chataway, and D. Wield. 2006. "Partnerships in African Crop Biotech". *Nature Biotechnology*, 24 (6): 619–621.
- Beintema, N. M., and G. Stads. 2006. *Agricultural R&D in Sub-Saharan Africa: An Era of Stagnation*. Washington, D.C.: International Food Policy Research Institute.
- Bezanson, K., S. Narain, and G. Prante. 2004. *Independent Evaluation of the Partnership Committees of the CGIAR: Final Report*. Washington, D.C.: CGIAR.
- Binenbaum, E. 2006. "Qualitative Analysis of R&D Consortia". Mimeo.
- Binenbaum, E., P. G. Pardey, and B. D. Wright. 2001. "Public-private Research Relationships: The

- Consultative Group on International Agricultural Research". *American Journal of Agricultural Economics*, 83 (3): 748–753.
- Byerlee, D. 1998. "The Search for a New Paradigm for the Development of National Agricultural Research Systems". *World Development*, 26 (6): 1049-1055.
- Byerlee, D., and K. Fischer. 2002. "Accessing Modern Science: Policy and Institutional Options for Agricultural Biotechnology in Developing Countries". *World Development*, 30 (6): 931–948.
- Buse, K., and G. Walt. 2000a. "Global Public-private Partnerships: Part I—A New Development in Health?". *Bulletin of the World Health Organization*, 78 (4): 549-561.
- Buse, K., and G. Walt. 2000b. "Global Public-private Partnerships: Part II—What Are the Health Issues for Global Governance?". *Bulletin of the World Health Organization*, 78 (5): 699-709.
- Chataway, J. 2005. "Introduction: Is It Possible to Create Pro-poor Agriculture-related Biotechnology?". *Journal of International Development*, 17 (5): 597–610.
- CGIAR (Consultative Group on International Agricultural Research). 2006. *Report on the Science Forum on CGIAR Priorities: Science for the Poor*. CGIAR Research Priorities 2005–2015. Rome: CGIAR Science Council Secretariat.
- CGIAR Science Council Secretariat. 2006. *CGIAR Center Collaboration: Report of a Survey*. Rome: Consultative Group on International Agricultural Research Science Council.
- Dalrymple, D. G. 2006. "Impure Public Goods and Agricultural Research: Toward a Blend of Theory and Practice". *Quarterly Journal of International Agriculture*, 45 (1): 71-89.
- Dar, W. D., and M. C. S. Bantilan. 2006. "Institutional Innovations Systems at ICRISAT: Facilitating Synergies in Agricultural Research for Development". Paper presented at an International Conference on Social Science Perspectives in Agricultural research and Development, New Delhi, India, February 15–18.
- Day-Rubenstein, K., and K.O. Fuglie. 2000. "The CRADA Model for Public–Private Research and Technology Transfer in Agriculture" in K.O Fuglie and D.E. Schimmelpfenning (eds.): *Public-private Collaboration in Agricultural Research: New Institutional Arrangements and Economic Implications*. Ames, Iowa: Iowa State University Press.
- deGrassi, A., and P. Rosset. 2003. "Public Research: Which Public is That?" URL: <<http://www.grain.org/publications/seed-03-07-4-en.cfm>>, accessed October 7, 2003.
- DFID (U.K. Department for International Development). 2003. *Key Sheets: Public–Private Partnerships*. London: Overseas Development Institute.
- Doering, D. S. 2005a. "Public–Private Partnership to Develop and Deliver Drought Tolerant Crops to Food-insecure Farmers. Draft Document for Discussion at the May 3–4, 2005, strategy and planning meeting. The Drought Tolerant Crop Initiative". Arlington, VA: Winrock International.
- _____. 2005b. "Public–Private Partnership to Develop and Deliver Drought Tolerant Crops to Food-insecure Farmers. Summary and interpretation of the May 3–4, 2005, strategy and planning meeting". Arlington, VA: Winrock International.
- _____. 2005c. "Bridge the Gaps: Drought Tolerant Crop Initiative" in IFPRI (ed.): *Pro-poor Public-private Partnerships for Food and Agriculture: An International Dialogue: Proceedings*.
- Doz, Y. 1996. "The Evolution of Cooperation in Strategic Alliances: Initial Conditions of Learning Processes". *Strategic Management Journal*, 17: 55–83.
- Ervin, D., T. Lomax, S. Buccola, K. Kim, E. Minor, H. Yang, L. Glenna, E. Jaeger, D. Biscotti, W. Armbruster, K. Clancy, W. Lacy, R. Welsh, and Y. Xia. 2003. *University-industry Relationship: Framing the Issues for Academic Research in Agricultural Biotechnology*. Proceedings from an expert workshop sponsored by the Pew Initiative on Food and Biotechnology and the U.S. Department of Agriculture's Initiative for Future Agriculture and Food Systems Project Public Goods and University-Industry Relationships in Agricultural Biotechnology. Charles Hammer Conference Center, November 19-20, Research Triangle Park, NC.
- EC (European Commission). 2003. *Guidelines for Successful Public-private Partnerships*. Brussels: European Commission.

- Evenson, R. A. and Y. Kislev. 1973. "Research and Productivity in Wheat and Maize". *Journal of Political Economy*, 81 (6): 1309–29.
- Fuglie, K. O., and D. E. Schimmelpfennig. 2000. *Public-private Collaboration in Agricultural Research: New Institutional Arrangements and Economic Implications*. Ames, Iowa: Iowa State University Press.
- Gisselquist, D., and C. van der Meer. 2001. *Regulations for Seed and Fertilizer Markets: A Good Practice Guide for Policy Makers*. Rural Development Working Paper 22817. Washington, D.C.: World Bank.
- Gowda, C. L. L., B. V. S. Reddy, K. N. Rai, and K. B. Saxena. 2004. "ICRISAT Collaboration with the Seed Industry in Asia". Paper presented at Asian Seed Congress 2004, Seoul, Korea, September 13–17, 2004. In APSA Technical Report No. 38. Bangkok: Asia and Pacific Seed Association.
- GRAIN (Genetic Resources Action International). 2001. "Apomixis: The Plant Breeder's Dream". URL: <<http://www.grain.org/publications/seed-01-9-2-en.cfm>>, accessed October 7, 2003.
- Hagedoorn, J., A. N. Link, and N. S. Vonortas. 2000. "Research Partnerships". *Research Policy*, 29: 567–586.
- Hall, A. 2005. "Capacity Development for Agricultural Biotechnology in Developing Countries: An Innovation Systems View of What It Is and How to Develop It". *Journal of International Development*, 17 (5): 611–630.
- _____. 2006. *Public Private Sector Partnerships in an Agricultural System of Innovation: Concepts and Challenges*. UNU-MERIT Working Paper. Maastricht, The Netherlands: United Nations University/Maastricht Economic and Social Research and Training Centre on Innovation and Technology.
- Hall, A., R. Sulaiman, N. Clark, and B. Yoganand. 2003. "From Measuring Impact to Learning Institutional Lessons: An Innovation Systems Perspective on Improving the Management of International Agricultural Research". *Agricultural Systems*, 78: 213–241.
- Hall, A., R. Sulaiman, N. Clark, M.V.K. Sivamohan and B. Yoganand. 2002. "Public-private Sector Interaction in the Indian Agricultural Research System: An Innovation Systems Perspective on Institutional Reform" in D. Byerlee and R. Echeverría (eds.): *Agricultural Research Policy in an Era of Privatization*. Oxon, U.K.: CABI.
- Herd, R. W. 2001. *Changing Priorities for International Agricultural Research*. Mexico City: CIMMYT.
- Horton, D., G. Prain, and G. Thiele. 2009. *Perspectives on Partnership: A Literature Review*. Working Paper 2009-3. Lima, Peru: International Potato Center (CIP).
- IFPRI (International Food Policy Research Institute) (ed.). 2006. *Pro-poor Public-private Partnerships for Food and Agriculture: An International Dialogue: Proceedings*. Washington, D.C.: International Food Policy Research Institute.
- Krattiger, A. 2002. "Public-private Partnerships for Efficient Proprietary Biotech Management and Transfer, and Increased Private Sector Investments". *IP Strategy Today*, 4–2002: 1–42.
- Linder, S. H. "Coming to Terms with the Public-private Partnership". 1999. *American Behavioral Scientist*, 43 (1): 35–51.
- Link, A. N. 2002. "Private-sector and Public-sector Strategies to Encourage Technological Alliances" in J. de la Mothe and A. N. Link (eds.): *Networks, Alliances and Partnerships in the Innovation Process*. Boston: Kluwer Academic Publishers.
- Lundvall, B. 1988. "Innovation as an Interactive Process: from User-supplier Interaction to the National System of Innovation" in G. Dosi, C. Freeman, R. Nelson, G. Silverberg, and L. Soete (eds.): *Technical Change and Economic Theory*. London: Pinter.
- Martin, S. and J. T. Scott. 2000. "The Nature of Innovation Market Failure and the Design of Public Support for Private Innovation". *Research Policy*, 29: 437–447.
- Metcalf, J. S. 1988. "The Diffusion of Innovations: An Interpretive Study" in G. Dosi, C. Freeman, R. Nelson, G. Silverberg, and L. Soete (eds.): *Technical Change and Economic Theory*. London: Pinter.

- Naseem, A. D.J. Spielman, and S.W. Omamo. 2010. "Private-sector Investment in R&D: A Review of Policy Options to Promote Its Growth in Developing-country Agriculture". *Agribusiness*, 26(1): 143-173.
- Nelson, R. R., and S. G. Winter. 1982. *An Evolutionary Theory of Economic Change*. Cambridge, MA: Belknap Press.
- NGOC (NGO Committee of the CGIAR). 2002. Statement by the NGO Committee of the CGIAR, October 30, 2002. URL: <<http://www.gmwatch.org/archive2.asp?arcid=367>>, accessed September 30, 2006.
- Özgediz, S. and A. Nambi. 1999. "Partnerships and Networks: Definitions, Forms, Critical Success Factors." Background Paper for the TAC-CGIAR Secretariat Review on Partnerships and Research: Lessons for the CGIAR. Washington, D.C.: CGIAR.
- Pardey, P. G., N. M. Beintema, S. Dehmer, and S. Wood. 2006. *Agricultural Research: A Growing Global Divide?*. Washington, D.C.: IFPRI.
- Parker, D., F. Castillo, and D. Zilberman. 2001. "Public-private Sector Linkages in Research and Development: The Case of U.S. Agriculture". *American Journal of Agricultural Economics*, 83 (3): 736-741.
- Patiño, B. O. and R. Best. 2002. "Strategic Alliances of Cassava Farmers with Private and Public Sectors: A New Approach for Development of the Cassava Crop in Latin America". Paper presented at the 9th Japan International Research Center for Agricultural Sciences (JIRCAS) International symposium on value addition to agricultural products, October 16-17, Ibaraki, Japan.
- Pingali, P. L. and G. Traxler. 2002. "Changing Locus of Agricultural Research: Will the Poor Benefit from Biotechnology and Privatization Trends?". *Food Policy*, 27: 223-238.
- Prasad, C. S., T. Laxmi, and S. P. Wani. 2006. *Institutional Learning and Change (ILAC) at ICRISAT: A Case Study of the Tata-ICRISAT Project*. Global Theme on Agroecosystems Report No. 19. Patancheru, India: ICRISAT.
- Pray, C. E. 2001. "Public-private Sector Linkages in Research and Development: Biotechnology and the Seed Industry in Brazil, China and India". *American Journal of Agricultural Economics*, 83 (3): 742-747.
- Pray, C. 2002. "The Growing Role of the Private Sector in Agricultural Research" in D. Byerlee and R. G. Echeverría (eds.): *Agricultural Research Policy in an Era of Privatization*. Oxon, U.K.: CABI.
- Pray, C. E. and K. Fuglie. 2001. *Private Investment in Agricultural Research and International Technology Transfer in Asia*. Economic Research Service Technical Report 805. Washington, D.C.: USDA.
- Rausser, G. 1999. "Private/Public Research: Knowledge Assets and Future Scenarios". *American Journal of Agricultural Economics*, 81 (5): 1011-1027.
- Rausser, G., L. Simon, and H. Ameden. 2000. "Public-private Alliances in Biotechnology. Can They Narrow the Knowledge Gaps between Rich and Poor?" *Food Policy*, 25: 499-513.
- Reid, D., D. Bussiere, and K. Greenaway. 2001. "Alliance Formation Issues of Knowledge-based Enterprises." *International Journal of Management Reviews*, 3 (1): 79.
- Reinhardt, F. 2004. *Nestle: Sustainable Agriculture Initiative*. Harvard Business School Report N9-705-018. Boston, MA: Harvard Business School Publishing.
- Reddy, B. V. S., A. J. Hall, and K. N. Rai. 2001. "The Long Road to Partnership: Private Support of Public Research on Sorghum and Pearl Millet" in A. J. Hall, B. Yoganand, V. Rasheed Sulaiman, and N. G. Clark (eds.): *Sharing Perspectives on Public-private Sector Interaction*. Proceedings of a Workshop. Patancheru, AP/New Delhi: ICRISAT/NCAP.
- Schaeffer, P. V. and S. Loveridge. 2002. "Toward an Understanding of Types of Public-private Cooperation". *Public Performance and Management Review*, 26 (2): 169-189.
- Smale, M., P. Zambrano, G. Gruère, J. Falck-Zepeda, I. Matuschke, D. Horna, L. Nagarajan, I. Yerramareddy, and H. Jones. 2009. "Measuring the Economic Impacts of Transgenic Crops in Developing Agriculture during the First Decade: Approaches, Findings, and Future Directions". *Food Policy Review* 10. Washington, D.C.: IFPRI.

- Spielman, D. J. 2006. "Pro-poor Agricultural Biotechnology: Can the International Research System Deliver the Goods?". *Food Policy*, 32 (2): 189-204.
- Spielman, D. J., J. I. Cohen, and P. Zambrano. 2006. "Will Agbiotech Applications Reach Marginalized Farmers? Evidence from Developing Countries." *AgBioForum*, 9 (1): 23–30.
- Spielman, D. J., and K. von Grebmer. 2006. "Public–private Partnerships in International Agricultural Research". *Journal of Technology Transfer*, 31 (1): 291–300.
- Spielman, D.J., F. Hartwich, and K. Von Grebmer. 2007. *Sharing Science, Building Bridges, and Enhancing Impact: Public–private Partnerships in the CGIAR*. IFPRI Discussion Paper No. 708. Washington, DC: IFPRI.
- Smith, J. 2005. "Contextbound Knowledge Production, Capacity Building and New Product Networks." *Journal of International Development*, 17 (5): 647–659.
- TIC (Technology Innovation Centre Foundation). 2005. Business Plan and Related Documentation. Mimeo. Patencheru, AP: ICRISAT.
- Traxler, G., and S. Godoy-Avila. 2004. "Transgenic Cotton in Mexico". *AgBioForum*, 7 (1&2): 57-62.
- Traxler, G., S. Godoy-Avila, J. Falck-Zepeda, and J. J. Espinoza-Arellano. 2003. "Transgenic Cotton in Mexico: Economic and Environmental Impacts of the First Generation Biotechnologies" in N. Kalaitzandonakes (ed.): *The Economic and Environmental Impacts of Agbiotech: A Global Perspective*. New York: Kluwer-Plenum Academic.
- Tripp, R. 2000. *Strategies for Seed System Development in Sub-Saharan Africa: A Study of Kenya, Malawi, Zambia and Zimbabwe*. Working Papers Series No. 2. Bulawayo, Zimbabwe: ICRISAT.
- _____. 2001. "Can Biotechnology Reach the Poor? The Adequacy of Information and Seed Delivery". *Food Policy*, 26: 249–264.
- Tripp, R., and N. Louwaars. 1997. "Seed Regulation: Choices on the Road to Reform". *Food Policy*, 22 (5): 433–446.
- USAID (United States Agency for International Development). 2004. *Tools for Alliance Builders*. Washington, D.C.: USAID.
- Von Hippel, E. 1988. *The Sources of Innovation*. New York: Oxford University Press.
- WEF (World Economic Forum). 2005. *Partnering for Success: Business Perspectives on Multistakeholder Partnerships*. Davos, Switzerland: WEF.
- Williamson, O. E. 1975. *Markets and Hierarchies*. London: Free Press, Collier Macmillan.
- _____. 1985. *The Economic Institutions of Capitalism*. New York: Free Press.
- _____. 1991. "Comparative Economic Organization: The Analysis of Discrete Structural Alternatives". *Administrative Science Quarterly*, 36: 269–296.
- World Bank. 2004. *The CGIAR at 31: An Independent Meta-evaluation of the Consultative Group on International Agricultural Research*. Washington, D.C.: Operations Evaluation Department, World Bank.



Of Choices and Dilemmas: Bt Cotton and Self-Identified Organic Cotton Farmers in Gujarat

Devparna Roy*

Abstract: Many proponents of organic farming, including well-known activists and NGOs, are vehemently opposed to the introduction of genetic engineering in agriculture and skeptical that biotechnology firms could in any way advance “chemical free” agriculture. But what do organic farmers themselves think of transgenic or genetically engineered seeds? The author interviewed thirty self-identified organic farmers in Gujarat state of India in 2004 and again in 2009. This article examines the responses of these self-identified organic farmers to Bt cotton, a non-food product of genetic engineering. Nearly half of these farmers consider Bt cotton to be compatible with their version of organic farming, and several of them adopted Bt cotton during the growing season 2003-04 and many continued that in 2009. This article attempts to understand why some of these organic farmers consider Bt cotton to be part and parcel of organic farming, why other farmers in this sample disagree with them, and why many of the farmers (irrespective of their beliefs about whether Bt cotton is part of organic farming or not) chose to adopt Bt cotton.

Keywords: Bt cotton, cotton, farmers, Gujarat, India, organic, transgenic, genetic engineering, seeds

Introduction

There are two approaches to agricultural production, which appear to be on a collision course, or which, at least, form the basis of an enduring controversy in rural India. The public debate on agricultural development, particularly in the news media and much of the scientific literature today, is sharply polarised between two paradigms: the agro-industrial (conventional farming) model and the agro-ecological (alternative farming) model.

The former paradigm relies on standardised technologies, monocultures, and ever-increasing fertiliser and pesticide use to provide additional food and fiber supplies for growing populations and economies. The latter emphasizes biodiversity, recycling of nutrients, synergy

* Assistant Professor, Department of Anthropology and Sociology, Hobart and William Smith Colleges, Geneva, NY, USA. Email: droy@hws.edu

among crops, animals, soils, and other biological components, as well as regeneration and conservation of resources. For most observers, genetic modification or genetic engineering is an example of a technology regime that falls under the category of agro-industrial approaches to farming, while organic farming¹ is an example of a technology regime that falls under the category of agro-ecological approaches to farming.

Until about fifteen years ago, organic farming was not considered as part of mainstream agriculture. However, these days, whole aisles of organic products appear in many grocery stores and command higher prices than products grown by conventional methods. There has been a corresponding upsurge of interest in the work done by researchers into organic methods.

All this has led to a harsh rhetorical work between advocates of conventional farming and proponents of organic farming. The above-mentioned ideals of the organic movement² have always set this movement squarely and implacably against intensive farming, chemical-based agribusiness, and genetic engineering-based agribusiness.

It is my contention, however, that behind the harsh rhetorical war between conventional farming and organic farming is a little-noticed convergence of views. For years, the study of organic farming sat on the margins of the Green Revolution in agriculture, as intensive farming techniques were adopted across the world and yields skyrocketed. But mainstream agronomists are becoming concerned about the long-term sustainability of this intensive approach to farming, and are focusing increasingly on soil integrity (Macilwain 2004). As is well known, soil integrity has long been a key concern of organic farmers. It is possible that groups on both sides of agriculture's great divide now want the same thing: soil integrity! As Mark Alley, an agronomist at Virginia Tech in Blacksburg puts it, "It's been a huge move. Twenty-five years ago, yield was everything. But in the past ten years, there's been a major recognition of the need to maintain organic materials in the soil" (quoted in Macilwain 2004:792). During the last few years, growing numbers of conventional farmers have started to adopt approaches that keep soil structure intact and cut the high levels of inputs that characterize intensive agriculture. It is fair to say, then, that though organic agriculture may not be the future of farming as such, key elements of the organic philosophy are nevertheless starting to be deployed in mainstream agriculture. For example, conventional farmers are reducing pesticide inputs, and thus

bowing to consumer pressure as consumer aversion to pesticides in their food builds up (Macilwain 2004).

The convergence of views between conventional farming and organic farming is a production of “paradigm shift” of some consequences in modern agriculture. Mainstream agriculture is borrowing elements from organic farming. But is the opposite taking place, i.e. is organic farming borrowing elements from mainstream agriculture? Evidence in the affirmative exists (Mansfield, 2004) and scholarly discussion has centered on ways that processes include institutionalization, standardization, and increasing industrialisation contribute to an erosion of organic production as an alternative to conventional production (e.g. Buck *et al.*, 1997; Guthman 2000; Rosset and Altieri 1997).

And does this convergence of views extend to the relationship between genetic engineering and organic agriculture? Probably not, because proponents of organic farming - activists such as Vandana Shiva and major NGOs such as IFOAM (International Federation of Organic Agriculture Movements) - remain vehemently opposed to the introduction of genetic engineering in organic agriculture³, and skeptical that firms such as Monsanto could in any way advance “chemical free” agriculture. These activists and NGOs argue that organic farming is a more sustainable alternative than genetic engineering. They maintain a conceptual firewall between genetic engineering and organic agriculture. However, as for farmers themselves, very little research exists to tell us whether the firewall is going up or coming down. There is little research on what organic farmers think about GMOs and whether they would grow transgenic crops.

This article examines the responses of thirty self-identified organic⁴ farmers in Gujarat (a state in western India) to Bt⁵ cotton, a non-food product of genetic engineering. To my surprise, I found that nearly half these farmers consider Bt cotton to be compatible with their version of organic farming and many of them have adopted Bt cotton. In this article, I shall attempt to understand why this is so, that is, why these producers consider Bt cotton to be part and parcel of organic farming, and why they are adopting Bt cotton.

Gujarat is one of the leading cotton-growing states of India. Since cotton farmers in Gujarat confront pests that threaten their crops, the interface between GM cotton and organic commitments is immediate and controversial. At the root of the controversy is the question whether Bt cotton - seeming anathema - will ever be deployed by Gujarat organic

cotton farmers and under what circumstances. I argue that at least some Gujarati organic cotton farmers employ a constructivist stance towards organic farming. By a “constructivist” outlook, I mean that which regards knowledge about organic farming as a human product, made with locally-situated cultural and material resources, rather than as simply the revelation of a pre-given order of nature. In this article, I make the point that many Gujarati cotton farmers are not satisfied with an inherent or essential definition of the term “organic.” This has deep implications for the technological treadmill for pesticides in India, for the shifting future of “organic” farming in India and elsewhere, and for Indian farmers faced with the question, to Bt or not to Bt.

The question of “what is organic” concerns farmers and everyday practices in India and takes us to positivist vs. constructivist uses of the term “organic.” According to Guba and Lincoln (1994), the ontological assumption of the positivist paradigm is that of “naïve realism” while that of the constructivist paradigm is “relativism.” In other words, positivists believe that an apprehendable reality exists, driven by natural laws and mechanisms. Knowledge of the “way things are” is conventionally summarized in the form of time- and context-free generalizations. Research can, in principle, converge on the “true” stage of affairs. In contrast, constructivists believe that realities are apprehendable in the form of multiple, intangible mental constructions socially and experientially based, local and specific in nature, and dependent for their form and context on the individual persons or groups holding the constructions. Constructions are not “true” in any absolute sense, but simply more or less informed, and/or sophisticated. Constructions are alterable, as are their associated “realities.”⁶

If “organic” is taken as a positivist category, then a gulf exists between organic farming and transgenic organisms and hybridity between organic and newly-engineered plant material is off the table. That is, if the social structure is such that organic farmers employ a positivist perspective, then these organic farmers will not grow transgenic crops. But if “organic” is taken as a constructed category, then it can be viewed as a “hybrid” category and there are lots of different factors and interests that go into that construction. If the social structure is such that organic farmers can employ a constructivist perspective, then these organic farmers are likely to adopt transgenic crops. I return to the term “constructivism” below, situating it in the discourse and debate of sociology. In this article, I interrogate the views of Gujarati self-identified organic farmers and

suggest that they are employing constructivist outlooks when it comes to the category “organic.”

I will first discuss the various meanings of “organicness.” Next, I will distinguish between the molecularist and organismic views of nature. I will follow this with a demographic portrait of the cotton farmers whom I interviewed in 2004. Next, I will present the views (as well as self-reported actions) of those who state that Bt cotton is not part of organic farming, those who hold the view that Bt cotton is part of organic farming, and those farmers who are undecided on this issue. I will conclude this article with an overview of different societies’ approaches to questions of hybridity, not only in biological terms, (i.e. hybrid seeds and transgenic seeds), but also in terms of beliefs and behaviors (i.e. growing transgenic seeds organically) and what this implies for the future of organic farming.

Meanings of “Organic”

The category “organic” holds different meanings to different people. To a chemist, cotton’s “organicness” stems from its molecular composition (Bunin 2001). The materiality of cotton makes it organic because the fiber contains carbon - the basis of all living (organic) matter. For organic farmers, organic means not using toxic chemicals, not worrying whether the food or fiber one grows looks blemish-free, and farming sustainably so that one can pass on one’s farm to a new generation of organic growers. For government regulators, like the United States Department of Agriculture (USDA), cotton’s “organicness” derives from adherence to a set of principles, practices and allowable farm inputs negotiated by diverse participants during the rule-making process (National Organic Farm Rule 2000).⁷ To a sociologist, cotton’s “organicness” emerges from decades of debates between social actors engaged in claims-making about the ideologies and practices that differentiate organic farming from modern, chemical-intensive agriculture.

There is nothing inherently “organic” about organic cotton: chemists, organic farmers, government regulators, sociologists, and others assign their own meanings to “organic” cotton (Bunin 2001). For purposes here, the “organicness” of cotton does not exist in the fiber itself, but rather in the meaning attributed to it by different individuals with stakes in creating organic ideologies, practices and institutional arrangements to authenticate organic farming and commodity production (Bunin 2001). Depending upon the particular purpose for which a given stakeholder uses the term “organic,” an array of meanings exist that respond to a continuum of

social concerns ranging from environmental protection, public health, worker rights, to consumer demands for the verification of organically produced commodities.

At a deeper level, conversations about what constitutes “organic” emanate from, and are made possible by, the particular histories and biographies of the society in which they take place (Mills 1959). Yet, as Gupta (1998) underscores in his book on Indian agriculture, knowledge rarely begins and ends within the confines of a strictly local milieu. Instead, it evolves through multiple processes of circulation, evaluation, contestation, resistance and reconfiguration that occur within different social and historical locations. For example, the British scientist Sir Albert Howard forged his notion of a composed-center, organic farming in collaboration with Indian farmers and published several foundational texts in Britain on organic agriculture, based on farm trials in India. As Bunin (2001) notes, nearly a century later, biodynamic practitioners from Britain and New Zealand taught farmers at the Maikaal Project in Madhya Pradesh, India, how to grow cotton organically, based upon a more refined understanding and practice of Howard’s methods developed in the neighboring city of Indore.

In India, a non-governmental organization based in Hyderabad, Deccan Development Society (DDS) pioneered the use of permaculture and gives importance to cultivation of traditional varieties. It is one of the NGOs that are opposing GM agriculture. Many Indian NGOs working with farmers in promoting sustainable/organic agriculture are popularizing System of Rice Intensification (SRI) which was originally developed in Madagascar.⁸ Thus, in contemporary times, what is organic agriculture or sustainable agriculture is a combination of practices, traditional/home-grown and adopted from elsewhere with different name. Although organic farmers in India are using traditional methods and traditional varieties, they are not averse to new techniques and methods.

Naturalness and Unnaturalness: Molecularist and Organismic Views of Nature

Let us now turn to the connections between organic farming and naturalness on the one hand, and biotechnology and naturalness on the other. By “naturalness” I mean something that is produced by nature, something that is not synthetic. What is the connection between organic farming and “naturalness”? As Foster and Burkett (2000) remark, the

term “organic” serves to denote the aspirations of philosophical ecology. Within contemporary Green theory, “organic” is often seen as a virtuous notion that reflects the essence of a deep ecological perspective. “Organic” connotes naturalness, connectedness, respect for living processes, a non-instrumental approach to nature and so forth (Foster and Burkett 2000). In contrast, “inorganic” suggests something that is nonliving, unconnected, and maybe even unnatural. The whole notion of “organic farming” - that is farming without pesticides and other harmful synthetic chemicals - further reinforces this conception of the organic as somehow representing the natural as opposed to the synthetic (Foster and Burkett 2000). Organic farming is thus viewed as natural by ecologists, and many other members of society including farmers.

With the exception of social constructivists, there is unanimous opinion that organic farming is natural, yet there is a divergence of views on whether genetic engineering is natural or unnatural. First, there is a divide between those who see genetic engineering as fundamentally unnatural and those who see it as a continuation of a process of human manipulation of “nature” that has been going on for at least 6,000 years (Herring 2001). For example, in the great “natural war” between trees and grasses, human beings have intervened on the side of grasses, creating things such as varieties of wheat, maize, rice, and millets (things we now consider quite “natural”) and destroying their competitors (the trees) by giving grasses privileged spaces or fields (Pollan 2001a⁹). According to some, genetic engineering enables this process of instrumental reconfiguration of plant genomes to proceed more rapidly and more precisely, and enable human beings to play god more efficiently (Herring 2001). Application of genetic engineering to agricultural biotechnology results in interplay among many ethical platforms and claims from both sides, i.e. proponents and opponents can be contested from different grounds without seeking recourse to a middle of the ground position (Stone, G. 2005).

Whether or not genetic engineering constitutes a fundamental break in manipulation of plant genetics represented by thousands of years of breeding depends in part on a more fundamental cognitive divide between an organismic view of nature and a molecularist view (Herring 2001). From the organismic perspective, putting a fish gene into a tomato - a common example used by opponents of genetic engineering - violates some threshold of the “natural”. From the molecularist view, there are no fish genes or tomato genes, just variable organizations of DNA: all

life is composed of the same material, just differently arranged. For the organismist, species constitute the natural world; to disturb this order is to assume the thoroughly unnatural role of god. It should be noted here that many people oppose genetically engineered (GE) crops because they adopt the organismic view of nature, i.e. they view GE crops as unnatural. As we shall see later in this article, many of the farmer I interviewed adopted an organismic view of nature and they found GE crops to be incompatible with genetic engineering. None of the farmers, however, adopted a molecularist view of nature, possibly because they were not trained in enough science to understand that all living organisms are composed of the same DNA.

Cotton Farmers in Central Gujarat

According to Menon (2003), about 50 per cent of the total area under cotton in Gujarat is occupied by indigenous or Asiatic varieties (*Gossypium arboreum* or *Gossypium herbaceum* which are short staple varieties.) The New World species, *Gossypium hirsutum*, is also grown in Gujarat (Main Cotton Research Station, GAU, Souvenir 1996). The indigenous or Asiatic types of cotton have been cultivated in Gujarat for thousands of years, and Gujarat has been a historically important center of cotton production and trade. Attempts to introduce the New World species *G. hirsutum* were first made in the eighteenth century. The world's first hybrid cotton Shankar IV (or H-4) was released in 1971 by Gujarat's Cotton Research Station located in Surat (a city in south Gujarat). Thus, Gujarati farmers were among the earliest farmers in the world to experiment with hybrid cotton. Today, Gujarati farmers grow many varieties of cotton - indigenous varieties, the New World variety *G. hirsutum*, hybrid varieties and transgenic cotton.

Many of the farmers in Gujarat are small farmers who can ill afford insecticides and other chemicals. Organic cotton is being grown willy-nilly by many farmers, according to the Gujarat Agricultural University, as most of the area under cotton in Gujarat is rain-fed and the poorer farmers cannot afford to grow cotton with pesticides or fertilizers (Menon 2003). The exact number of organic farmers is not available. According to Menon (2003), most of the organic cotton farmers are scattered here and there, and in many cases, we see isolated farmers practicing organic farming out of religious belief or a commitment to not using pesticides. Moreover, there is a sizeable number of farmers in Gujarat who grow organic cotton because of Gandhian influence. Gujarat is one of the states where, due to Gandhian influence, people like Mahendra Bhatt, Badribhai Joshi, Rajni

Dave and some others talked about organic farming way back in the 1970s (Menon 2003). Today, there is a younger generation of activists (most of whom are associated with NGOs) who are working for organic farming in the state (Menon 2003).

My primary data sources for this article are in-depth interviews with thirty farmers conducted in summer 2004.¹⁰ These thirty farmers hailed from different parts of Vadodara district, which is located in central Gujarat. Snowball sampling method was used to identify the interviewees. Though none of the farmers had been certified by any agency as “organic” farmers, all thirty farmers identified themselves as organic farmers. None of the farmers are selling their cotton as “organic cotton” though the cotton is grown without chemical fertilizers and chemical pesticides. The farmers sell their cotton in the open market at the same price as conventionally-produced cotton, i.e. they do not get a premium price for their cotton.

The thirty farmers can be divided into three groups. The first group is that of farmers who claimed that Bt cotton is incompatible with organic farming. Farmers belonging to the second group stated that Bt cotton is part and parcel of organic farming. Those belonging to the third group were undecided on the question of whether Bt cotton was compatible or not with organic farming. Each of these three groups contained farmers who grew Bt cotton in 2003-04 and who were planning to grow Bt cotton in 2004-05.

In what follows, I will discuss the three groups of farmers in terms of whether they claimed that Bt cotton was part of organic farming (or not), and what they actually did in practice (i.e., whether they grew Bt cotton or not). Several of the organic farmers interviewed claimed that Bt cotton was not part of organic farming, but actually adopted Bt cotton in practice; several of the organic farmers interviewed claimed that Bt cotton was part of organic farming but did not adopt Bt cotton in practice. Let us try to their constructivist views as practitioners of organic agriculture.

Demographic Portrait of the Interviewees

Even though the demographics of the farmers may not have any connection with their views on genetic engineering, it is useful to give a demographic portrait of the interviewees to offer a sense of the individuals who participated in the research project. Interviews were carried with with farmers in their homes or fields. Each interview was about 45 minutes to an hour in length, and each interview was tape-recorded with the permission of the farmer. I found that all farmers were surprisingly eager to share their

experiences of organic agriculture and all the organic farmers approached gladly agreed to be part of the research project.

Out of the thirty farmers, twenty-eight were men while two farmers were women. The ages of farmers ranged from 30 years to 68 years (during the year 2004). The mean age of the farmers was 48 years. As far as education was concerned, fifteen of the thirty farmers were with bachelor's degrees and there were two farmers with master's degrees. One farmer was illiterate, two had attended some years of secondary school, five had completed Standard 10, one had completed Standard 12, while four had attended some college.

Twenty-five out of the thirty farmers, or 83 per cent, had either large or medium landholdings by Indian standards. Seventeen out of the thirty farmers had large landholdings by Indian standards, i.e. their fields were more than 24.7 acres (10 ha) in size. Eight of the thirty farmers had medium landholdings, i.e. their fields were between 9.88 acres and 24.7 acres (4 ha to 10 ha) while three of the farmers had semi-medium landholdings, i.e. their fields were between 4.94 acres and 9.88 acres (2 ha to 4 ha). Only two of the farmers had marginal landholdings, i.e. their fields were less than 2.47 acres (1 ha). The range of total acres farmed was from 1.71 acres to 142.5 acres (0.68 ha to 57.69 ha), with a mean value of 35.04 acres (14.2 ha). The range of cotton acres farmed was from 1.14 acres to 131.1 acres (0.5 ha to 53 ha), with a mean value of 19.53 acres (7.9 ha).

Twenty-nine farmers possessed means of irrigating their land and they had either fully irrigated cotton or semi-irrigated cotton. Except for two farmers, the rest of the farmers kept cattle (cows or buffaloes or bullocks), which are useful source of manure (used as organic fertilizer). The farmers grew a multitude of other crops besides cotton, such as paddy, wheat, pigeon pea, green gram, castor, corn, cumin, lentils, tobacco, pearl millet, groundnut, vegetables, bananas, or soybean. The thirty farmers had been practicing organic farming for different lengths of time, i.e. some had been organic farmers for ten years or more, while others were more recent converts to organic farming.

There were twelve farmers who believed that Bt cotton is not part of organic farming; the range of operational holding for this group of farmers ranged from 2 acres to 70 acres (0.8 ha to 28.3 ha) and the average size of operational holding for this group was 24.9 acres (10 ha). There were thirteen farmers who believed that Bt cotton is part of organic farming; the range of operational holding for this group ranged from 1.7 acres to 142.5 acres (0.7 ha to 57.7 ha) and the average size of operational holding

for this group was 44.3 acres (17.9 ha). There were five farmers who were undecided on the issue of whether or not Bt cotton is part of organic farming; the range of operational holding for this group was from 6.8 acres to 70 acres (2.7 ha to 28.3 ha) and the average size of operational holding was 31.4 acres (12.7 ha).

Based on my literature search, I had expected that all organic farmers would believe that first, organic farming is “natural,” and second, that genetically modified organisms such as Bt cotton cannot be part of organic farming. In practice, however, I found that while all thirty farmers shared the view that organic farming is natural, nearly half of my sample believed that Bt cotton is part of organic farming. Additionally, I found that a number of farmers who believe that Bt cotton is not part of organic farming actually grow Bt cotton in practice.

Group I: Farmers Who Believe that Bt Cotton Is Not Part of Organic Farming

Prominent NGOs (located in developed countries as well as developing countries) and the United States government claim that Bt cotton is not part of organic farming. Twelve farmers in my sample agreed with this mainstream view that Bt cotton is not part of organic farming. For all twelve farmers, organic farming is natural. However, nine farmers expressed organismic views regarding genetic engineering; they gave organismic reasons as to why Bt cotton could not be considered as part of organic farming. These nine farmers subscribed to the organisms view that by transferring genes between species (bacterium and plant, in this case), “unnatural” objects are created. Five farmers held the view that there is negative impact of Bt cotton on soil fertility, while one farmer did not consider Bt cotton to be part of organic farming because she believed that chemical inputs are necessary in order to grow Bt cotton. What follows are comments from the first group of twelve farmers.¹¹

One of these twelve farmers, Ajaybhai Patel¹², said, “Bt cotton cannot be considered as part of organic farming because the seeds get treated with a chemical and Bt genes provide disease-resistance. There is a new chemical in Bt plant. There is a new poison or toxin in the Bt plant as pests cannot eat it and survive. Hence Bt cotton is part of chemical farming.”¹³ Another farmer, Amanbhai Patel, compared Bt cotton with a test-tube baby. He said, “Bt cotton is not part of organic farming as a gene has been inserted in it. It has lost its originality. It is artificial. It is like a test-tube baby, isn’t it?”

The original seeds are not there.” According to another farmer, Kishorbhai Patel, “There is a gene inserted in the Bt cotton plant, and it is unnatural” and that was why Bt cotton is not part of organic farming. Paragbhai Patel, Shyambhai Patel and Gautambhai Patel were three other farmers who said that Bt cotton is not natural as a foreign gene has been inserted into it, and therefore it could not be part of organic farming. Gautambhai Patel expressed the opinion that he grows F_2 seeds of Bt cotton because “Bt gene expression is less in F_2 seeds compared to F_1 seeds, and hence F_2 seeds spoil the soil less compared to F_1 .”

Jatinbhai Patel was another farmer who said that Bt cotton was not part of organic farming. According to him, “There is something in the Bt cotton plant that does not let green bollworms attack the plant. It is possible that soil bacteria are destroyed by the same toxin which prevents pests from attacking the plant. That is not taken into account.” He expressed concern that the soil fertility would go down because of the toxins present in the Bt cotton plant. Kishorbhai Patel also expressed concerns that the soil fertility would go down because of the Bt gene that has been inserted into the cotton plant.

Three other farmers expressed concerns about the impact of Bt cotton on soil fertility. This is important because soil the concept of soil fertility is central to the idea and practice of organic farming. A farmer, Dahyabhai Patel, said that he had heard that if one grows Bt cotton, then the soil gets spoiled as some of the useful bacteria in the soil dies. He claimed that he had practically seen that if one grows Bt cotton on the same plot of land for three years continuously, then the Bt cotton fails to give good yield in the third year. He added, “I have seen this in person. It happened in a field belonging to someone else that is adjoining my tube well. I have seen that this person did Bt cotton for three continuous years and the Bt cotton crop is a failure during the third year. He won’t recover the labour costs even. He will go into loss hundred percent. If you do Bt cotton continuously, then there is not yield in the third year. The plant growth is stunted and there is no yield.”

Mukulbhai Patel was a farmer who said that Bt cotton is not part of organic farming because it is artificial as a foreign gene has been inserted into the cotton plant. He added that he had read in the newspapers about three years ago that “if you grow Bt cotton for five years then nothing will grow on that soil.” He said he did not have further knowledge about this topic. A third farmer, Amodbhai Patel said that organic farmers should

not grow Bt cotton because “if you grow Bt cotton for a long time, it will affect soil fertility and nothing will grow on that soil.”

There was only one female farmer in this group, Nishaben Patel, who said that from the experience of other farmers, she has learned that chemical fertilisers have to be used with Bt cotton, or else plant growth is stunted. She also learned from these farmers that chemical pesticides have to be used in Bt cotton in the early stages of growth. Since for Nishaben Patel, organic farming means farming without chemical fertilisers and chemical pesticides, she has decided not to grow Bt cotton.

Another farmer expressed concern about the “foreign origins” of Bt cottonseed and whether seeds developed in colder climates would do well in the tropical climate of India. When asked as to whether Bt cotton was part of organic farming, Bakulbhai Patel replied: “I believe that those who do organic farming should not do anything that goes against the laws of nature. You can prepare hybrid seeds locally. You can use hybrids that have been crossed locally. But foreign seeds and foreign genes are not useful for our local soils and environments. Let me give one example. Some Indian farmers bought Jersey and Holstein cows from abroad. But despite giving them more food and good treatment, they were not able to produce enough milk as they did in foreign countries. The cost of maintaining these cows was high and the farmers accumulated debts as a result. Similarly, in the case of grains and seeds, there is no advantage to Indian farmers if we bring foreign seeds to India because India is a tropical country and the seeds of cold countries will not do well here.”

Group I Farmer Words vs. Deeds

There is a long-standing interest in both sociology and social psychology on the discrepancies between words and deeds. For example, the famous sociologist C. Wright Mills identified the “disparities between talk and action” as the “central methodological problem of the social sciences” (Mills 1963). About forty-five years ago, Deutscher (1966) stated that we still do not know much about the relationship between what people say and what they do - attitudes and behaviour, sentiment and acts, verbalizations and interactions, words and deeds. Under what conditions will people behave as they talk? Under what conditions is there no relationship and under what conditions do they say one thing and do exactly the opposite? Deutscher (1966) comments that in spite of the fact that all of these combinations have been empirically observed and reported, few efforts have been made

to order such observations.

The twelve farmers believed that Bt cotton could not be part of organic farming due to various reasons such as the “unnaturalness” of Bt cotton, negative impact of Bt cotton on soil fertility, and the need for chemicals to grow Bt cotton. However, in practice, nine out of the twelve farmers grew Bt cotton in the year 2003-04.

Why do these farmers adopt Bt cotton? Once again, their words are revealing. While expressing fear that Bt cotton would affect the soil fertility negatively, Anilbhai Patel said that he has to grow Bt cotton because he has a large family and he has no other source of income. He has to marry off three daughters. He explained that if he grew non-Bt cotton, then he would have to use chemical pesticides. He added, “But in Bt cotton, I don’t have the expense of pesticides and I get good yields. So I do Bt cotton. Bt cotton is not part of organic farming but I have to grow Bt cotton.” He grew the transgenic varieties Navbharat 151 and Navbharat 251 in 2003-04 and he had planned to grow four transgenic varieties of Bt cotton (Navbharat 151, Navbharat 251, Balram 151 and Dhanlaxmi) the following year. Two other farmers, Paragbhai Patel and Kishorbhai Patel, said that they grew Bt cotton in 2003-04 because they didn’t want to incur the high costs of pesticides.

Besides the costs of pesticides, the high yields of cotton were cited as another reason as to why several farmers were growing Bt cotton. A farmer, Ajaybhai Patel, emphasized that in order to stay financially competitive with non-organic and other organic farmers, he was forced to use Bt cotton. He said, “If we don’t use Bt cotton for two years or five years, then we will be backward in terms of financial success. So, to stay in the competition, we have to use Bt cotton at least once.” Paragbhai Patel said that he was growing Navbharat 151 because he gets more yields from that variety. The same reason - high yields of Bt cotton - was given by Shyambhai Patel. He said he had not grown Bt cotton in 2001-02 and 2002-03 because of his belief that Bt cotton is not part of organic farming. However, in 2003-04, he had grown Bollgard on trial basis. He explained, “To stand in the competition in the open market, we need to grow better-yielding varieties of cotton. That is why I am trying out Bollgard on trial basis.”

Amanbhai Patel said he had sown Bt cotton in 2003-04, and he had got high yields with it. And that was the reason he would be growing Bt cotton again the following year. Kishorbhai Patel said that he had chosen to grow Navbharat 151 F₁ because he had observed other farmers getting

good yields with Navbharat 151 F₁. He said he did not use Bollgard seeds because they are costly. According to him, the yields are approximately the same for the legal Bollgard and the unauthorized Bt cotton varieties. But since production costs are comparatively lower in the unauthorized Bt cotton varieties (due to less consumption of pesticides and lower costs of seeds), the profit margin is more for the unauthorized Bt cotton varieties compared to Bollgard varieties.

Jatinbhai Patel had grown Shankar X, Gujarat 21, Gujarat 23 and Dr. Sarju Bt in 2003-04¹⁵. He bought a packet of Dr. Sarju Bt seeds for Rs. 325 at the Rajkot agricultural fair. He grew Dr. Sarju Bt on 0.3 acres in order to do Bt cotton on trial basis. However, he considers indigenous varieties to be superior to Bt varieties and hybrid varieties because indigenous varieties require less attention from the farmer. So he has decided to grow Deviraj (an indigenous variety) the following year rather than grow any Bt varieties.

Dahyabhai Patel said that he had grown Bt cotton, Chamatkar (a hybrid) and Gujarat 23 in 2003-04 in order to learn about the plus and minus points of growing each variety, and to learn about the profits of growing each variety. He said he learned that indigenous varieties such as Gujarat 23 are good for those who want to get good yields at less cost. He said that F₁ of Bt cotton gives good yields and the market price is good too. But there are too many diseases in F₂ of Bt cotton. He held the opinion that one should not cultivate F₂ of Bt cotton; it is better to grow indigenous varieties rather than grow Bt cotton F₂ as 'there are no headaches if you grow indigenous varieties.'

Mukulbhai Patel had grown Navbharat 151, Gujarat 21 and Gujarat 23 in 2003-04 to check out the three varieties on a trial basis. His opinion was that Gujarat 21 and Gujarat 23 were better than Navbharat 151 because the production cost was almost nothing in the indigenous variety, and there is no attack by sucking pests and bollworms on indigenous varieties, so there is no need to spray pesticides.

Eight of the twelve farmers said they would grow Bt cotton the following year. Of these eight farmers, two said they would grow Bollgard cotton; one said he would grow Rasi Company's RCH-2 Bt¹⁶ the following year, and the rest said they would grow unauthorized varieties of Bt cotton. Three farmers - Bakulbhai Patel, Jatinbhai Patel and Mukulbhai Patel - said they would not grow Bt cotton the following year, but they would grow other varieties of cotton. Bakulbhai Patel planned to stick with Shankar X, the variety that he grew in 2003-04. Jatinbhai Patel (who had grown

Gujarat 21, Gujarat 23, Shankar X and Dr. Sarju Bt in 2003-04) said he would grow an indigenous variety Deviraj in 2004-05. Mukulbhai Patel (who had grown Gujarat 21, Gujarat 23, Navbharat 151 in 2003-04) said he would grow two indigenous varieties Gujarat 21 and Gujarat 23 in 2004-05. One farmer, Nishaben Patel, said she would not grow cotton the following year.

Group II: Farmers Who Believe That Bt Cotton Is Part of Organic Farming

In contrast to the organismic view stated earlier, thirteen out of the thirty farmers said they considered Bt cotton to be part of organic farming. Out of these farmers, four held the opinion that since a gene (existing in nature) has been transferred to cotton plant to create the Bt cotton plant, organic farmers can grow Bt cotton. In their opinion, a pesticide has not been transferred from the soil bacterium to the plant, i.e. by transferring the naturally-occurring gene, scientists has merely enabled the Bt cotton plant to make a pesticide on its own. Furthermore, the Bt toxin exists in nature as a toxin produced by the soil *bacterium Bacillus thuringiensis*. In other words, the Bt plant is manufacturing a natural pesticide. Hence, Bt cotton is part of organic farming.

Four farmers in this group held the belief that there is no negative impact of Bt cotton on soil fertility, and hence Bt cotton could be considered part of organic farming. Three farmers considered Bt cotton to be part of organic farming because of high yield and good profit margin. Three farmers considered Bt cotton to be part of organic farming because organic fertilizers and organic ways of killing pests could be used to grow Bt cotton. Three farmers considered Bt cotton to be part of organic farming because Bt cotton plants can combat pests if the farmer uses organic methods of killing pests. It should be noted that none of the farmers subscribed to a molecularist view of nature although four of them held the opinion that transferring a gene from bacterium to plant is not the same thing as transferring a pesticide.

Farmer Ravibhai Patel believed that Bt cotton is part of organic farming because the “genes that are put in the cotton plant are not considered to be pesticides by us. It is not that pesticides have been put inside the plant.” But he also cautioned that research on the effects of Bt gene on the environment has still to be carried out. However, another farmer Pravinbhai Patel held the opinion that there are no negative results on the soil microorganisms if Bt cotton is grown.

Other farmers said that Bt cotton is considered as part of organic farming because the yields are comparatively higher and the profit margin is good. Amritbhai Patel said, "I have to say that some people, especially the teachers in the universities and researchers, are saying that Bt cotton is not advisable for farming. Farmers used to do Shankar VI and Shankar VIII and they used pesticides and they used to be ruined by the cost of pesticides. In comparison, farmers get a lot of satisfaction from use of Bt cotton and the margin of profit is also good. After all, whatever business we do, we have to worry about the profit margin. If the profit margin is good, then that business is considered good. That is why people are growing Bt cotton nowadays." He added that people don't know as yet if there are any side effects of Bt cotton. He held the view that farmers would stop growing Bt cotton if there were any side effects. Another farmer Vishnubhai Patel held the view that organic farmers can grow Bt cotton to get higher yields.

Farmer Chintanbhai Patel held the view that Bt cotton is part and parcel of organic farming because of the higher productivity of Bt cotton compared to other varieties. He added that we don't know about the adverse effects of Bt cotton on the soil. If farmers learn that there are adverse effects of Bt cotton on the soil, then there will be no question of using it. Until that happens and since farmers need high yields, it is okay for organic farmers to use Bt cotton. He didn't foresee any risks of using Bt cotton for the next one or two years, but he was worried that since the seeds are genetically modified, something may happen to the soil. He was of the opinion that the government should decide what the risk factors are and the government should give guidance to the farmers regarding Bt cotton.

Farmer Kishanbhai Patel was of the opinion that organic farmers can grow Bt cotton as non-synthetic fertilizers such as cow dung manure can be used to grow Bt cotton, and herbal pesticides could be used to grow Bt cotton. Farmer Hiteshbhai Patel held a similar opinion. He said that organic farmers can grow Bt cotton but it would take time for the plant to grow if only organic fertilizers were used. Farmer Chamanbhai Patel said that he heard that one doesn't have to spray pesticides if one grows Bt cotton. That is why he decided to grow Bt cotton. He knew that there is a toxin or material in the Bt cotton plant that prevents American bollworms from eating any part of the plant. He said that he believed that Bt cotton is a good variety and organic farmers should grow Bt cotton.

Another farmer, Ashimbhai Patel, held the view that Navbharat 151 is good for organic farming because very few pesticides have to be sprayed on it. It requires pesticides only for sucking pests. One could spray organic insecticide made from cow's urine on Navbharat 151 for dealing with sucking pests. So he considered Navbharat 151 as a good variety for organic farming.

Farming Nalinbhai Patel said, "Actually, Bt is a soil bacterium. It is not a chemical substance. Scientists have taken a gene from *Bacillus thuringiensis*. In organic farming, Bt powder is used. The government of India has approved the use of Bt powder and it gives Bt powder at 50 per cent subsidy. Hence Bt is not going to harm anything. Bt is a soil bacterium that destroys certain bollworms. Bt is not a chemical. That is why organic farmers can use Bt cotton."

Another farmer, Vikrambhai Patel, said that Bt cotton is part of organic farming. He commented, "They have inserted a gene into the plant and it is a good effort. We just have to buy the seeds and sow the seeds in our soil. We don't have to do anything else. There are no problems. The soil quality is not going to get harmed. I have heard that the pests die upon eating the protein or poison in the plant."

Farmer Sarojben Patel held the same opinion and she did not think that the Bt cotton plant was unnatural because a gene had been inserted into it. She said that organic farmers could grow Bt cotton.

Another farmer, Vinodbhai Patel, said that Bt cotton is part of organic farming because organic fertilizers and herbal pesticides can be used to grow Bt cotton, even though the organic inputs take longer time to show results. He compared organic fertilizers and herbal pesticides to pills that a doctor gives. In his words, "When a doctor gives injection, the patient gets well on the spot, whereas if he gives pills, the patient takes a longer time to get well. The chemical fertilizers and pesticides are like injection, as you get results immediately. The organic fertilizers and herbal pesticides take longer time to show results."

Group II Farmer Words vs. Deeds

Nine out of the thirteen farmers in Group II grew Bt cotton in the year 2003-04. Five farmers planted Bt cotton in 2003-04 because they believed that they would get higher yields from Bt cotton compared to other varieties of cotton. Two farmers planted Bt cotton because they believed that Bt cotton does not need pesticides. One farmer, Vikrambhai Patel, said

that he had planted F_1 of Navbharat 151 on trial basis and he was going to plant five varieties of Bt cotton in 2004-05 on trial basis too. Another farmer, Vinodbhai Patel, said he had grown F_1 of Bt cotton because of less pest incidence, and also because the net weight of Bt cotton bolls is good, and the staple length is good too.

Here is some information about the four farmers who did not grow Bt cotton in the year 2003-04. Chintanbhai Patel had grown only Shankar X in 2003-04, but he was planning to grow Bollgard 162, Gujarat 23, and Digvijay in 2004-05. Vishnubhai Patel had grown Shankar VIII and Shankar X in 2003-04, but he planned to grow Navbharat 151 F_1 and Navbharat 151 F2 in 2004-05. Nalinbhai Patel had grown Shankar VIII in 2003-04 but he planned to grow Bt cotton (he did not specify the variety) in 2004-05. Sarojben Patel had grown Chamatkar in 2003-04.

Eleven out of the thirteen farmers in Group II said they would grow Bt cotton in the year 2004-05. Here is some information about the other two farmers. The first farmer is Sarojben Patel who was undecided about what variety of non-Bt cotton to plant in 2004-05. The second farmer was Ashimbhai Patel who had grown Navbharat 151 F_1 in 2003-04 and was planning to grow Chamatkar (a non-Bt variety) in 2004-05. He said, "I have no wish to grow Navbharat 151 again. Chamatkar is a variety you can grow without any tensions. You get good production with less effort in the case of Chamatkar. He said that he faced tensions while growing Navbharat 151 because sucking pests attack Navbharat 151 and the sucking pests do not submit to control even after spraying herbal pesticides. The cotton bolls got spoiled as a result.

Group III: Farmers Who are Undecided about Whether Bt Cotton is Part of Organic Farming

Finally, five out of the thirty farmers expressed uncertainty about whether Bt cotton is part of organic farming or not. Pratikbhai Patel said that 2004-04 was the first year he was growing Bt cotton and he would find out that year whether Bt cotton suited organic farming nor not. Another farmer, Jigneshbhai Patel said that almost all farmers in his district were growing Bt cotton, whether they were organic farmers or not, but he was personally unsure about whether Bt cotton could be grown by organic farmers. He had grown Shankar X (non-Bt cotton) in 2003-04 but he was planning to grow F_1 of Navbharat 251 (Bt cotton) in 2004-05.

Farmer Rameshbhai Patel said he would grow Bt cotton after checking out the experiences of organic farmers who were growing Bt cotton in

2004-05. He had grown Bunny (non-Bt cotton) in 2003-04 and he would be growing Chamatkar (non-Bt cotton) in 2004-05. The fourth farmer, Chanchalbhai Patel said that he grew Chamatkar (non-Bt cotton) in 2003-04 and he would grow Chamatkar again in 2004-05. He did not have any experience with Bt cotton and he was not sure if Bt cotton harmed the soil or not. In his opinion, there was no clear-cut answer anywhere as to whether Bt cotton was harmful to the soil and harmful to human health. He was not sure whether feeding Bt cottonseeds to animals caused problems or not, and whether cottonseed oil consumption by human beings caused problems or not. So he did not grow Bt cotton. The fifth and final farmer, Girishbhai Patel, felt that he was personally unsure about whether Bt cotton is part of organic farming or not. He had grown three cotton varieties in 2003-04, including a Bt cotton F₂ variety. He was growing only Bt varieties in 2004-05 (Shankar X Rakshak, Dhanlaxmi, RCH-2).

The views of each of the three groups of farmers have been presented so far. The interests and existential factors behind each farmer's construction (of whether genetically engineered seeds are compatible or incompatible with organic farming) have been explored and digested. The interests and existential factors do not follow a discernable pattern, leaving me no way to predict (based on demographic characteristics and the kinds of crops grown) whether a given farmer will take the view that transgenic seeds are compatible with organic farming or not.

Conclusions

As I have argued earlier, a "constructivist" position seems to be at work among the organic farmers in Gujarat and should be taken seriously. By "constructivism," I mean an outlook which regards knowledge about organic farming as a human product, assembled with local cultural and material resources, rather than simply the revelation of a pre-conceived order of nature. As the interviews with farmers demonstrate, the category of "organic" is constructed, i.e. it can be viewed as a hybrid category comprising of many different factors and interests. None of the thirty farmers are satisfied with an essentialist definition of the category "organic." They have their own definitions and informed opinions as to whether Bt cotton can be construed as part of organic farming. To Bt or not to Bt, then, is a function of the controversies, farmers' exposure to these controversies, and practical implications of these controversies for farmers' livelihoods. Their constructions appear random and do not systematically relate to their demographics, at least among the thirty farmers whom I interviewed.

As I have suggested earlier, at the broader societal level, there is a convergence of views between organic farming and mainstream farming because conventional farmers are focusing increasingly on soil integrity and on reduction of pesticide use. Organic production is also becoming more like conventional farming due to the processes of institutionalization, standardization, and increasing industrialization. However, according to my literature search, the exception to this convergence appears to be between organic farming and genetic engineering. Proponents of organic farming, both individual activists and NGOs, appear in general, vehemently opposed to the introduction of transgenic seeds in organic agriculture. However, there is not much research on this exceptional case enlightening us as to what organic farmers themselves think about genetic engineering and why.

Several of the thirty self-identified organic farmers in Gujarat I engaged with maintain that genetic engineering is compatible with organic farming because genes - not pesticides - have been inserted into the cotton plant. The genetically engineered cotton plant produces a natural pesticide. However, those farmers who believed that genetically engineered organisms are not part of organic farming argued the opposite; for them there was a new toxin or pesticide present in the cotton plant, so it was unnatural. They held that a gene from a bacterium has been inserted into the cotton seed, so it is unnatural. Thus, these farmers subscribe to an organismic view of nature. However, the farmers who believed that genetically engineered organisms are part of organic farming did not subscribe to a molecularist view of nature

Another divide in Gujarat farmers was on the question of soil fertility. The farmers who believe that genetically engineered organisms are part of organic farming also argued that there are no side-effects of Bt cotton on soil fertility while the farmers who believe that genetically engineered organisms are incompatible with organic farming argued that there is a negative impact of Bt cotton plant on soil fertility. So far, scientists have not been able to demonstrate any direct negative impact on the soil due to Bt cotton plants, but there are plenty of rumors circulating in Gujarat that Bt cotton has a negative impact on soil microbial population. It is possible that use of tractors and less application of manure leads to compaction of the soil in case of chemical farming; and this compaction of the soil could lead to a negative impact on certain soil microbial populations.

A third point of controversy among cotton farmers in Gujarat was on the question of fertilizers and pesticides. One farmer who believed that Bt

cotton is not part of organic farming held the view that chemical fertilisers and chemical pesticides are a must to grow Bt cotton. However, several farmers who believed that Bt cotton is part of organic farming also believed that organic fertilisers and herbal pesticides are enough to grow Bt cotton, and there is no need for synthetic fertilisers and synthetic pesticides. One farmer compared synthetic chemicals to the injections that a doctor gives, and he compared organic fertilisers and herbal pesticides to the pills that a doctor gives. In his opinion, the injection has an immediate effects (and so do the synthetic fertilisers and pesticides), while the pills have a slow but enduring effects (and so do organic fertilisers and pesticides).

A fourth interesting finding is that nine of the twelve farmers who believed that Bt cotton is not part of organic farming actually grew Bt cotton in 2003-04. Eight of those farmers said they would be growing Bt cotton in 2004-05 and the majority said they would be growing unauthorized varieties of Bt cotton. Nine out of the thirteen farmers who believed that Bt cotton is part of organic farming actually grew Bt cotton in 2003-04. Eleven out of the thirteen farmers were planning to grow Bt cotton in 2004-05, and the majority said they would be growing unauthorized varieties of Bt cotton. Among the five farmers who were undecided as to whether transgenic seeds were part of organic farming or not, only one had grown Bt cotton in 2003-04, while three were contemplating about growing Bt cotton in 2004-05. Out of the sample of thirty farmers, nineteen had grown Bt cotton in 2003-04, and twenty-two farmers said they would be growing Bt cotton in 2004-05.

Thus, according to almost half the farmers in my Gujarat sample, "organic" farming was a hybrid category, which incorporated both non-transgenic organisms and transgenic organisms. It may be asked: why did such hybrid categories of the term "organic farming" emerge in Gujarat? Here, I can only speculate. One answer to this question comes from Haraway's (1997) views on transgenics or genetically engineered organisms. Haraway (1997) comments that in opposing the production of transgenic organisms, committed Western activists appeal to notions such as the integrity of natural kinds and the natural telos or self-defining purpose of all life forms. For these Western activists, transferring genes between species transgresses natural barriers, comprising species integrity. Haraway (1997) argues that the distinction between nature and culture in the West has been a sacred one. She argues that transgressive border-crossing pollutes lineages - in transgenic organism's case, the lineage of nature itself - transforming

nature into its binary opposite, culture. The line between the acts, agents, and products of divine creation and human engineering has given way in the sacred-secular border zones of molecular genetics and biotechnology, as biotechnologists produce unions across taxonomic kingdoms (not to mention nations and companies) daily in their laboratories.

Latour (1993) has argued that hybrids proliferate in the middle kingdom, between society and nature and purification as a neat separation is problematic while hybridization involves mixtures of nature and culture. Thus, depending upon the perspective GMOs can be treated as

- 1) hybrids that blur the distinction between organic and un-natural/synthetic and hybrids that proliferate on account of the blurred boundaries and technological possibilities that transfer 'natural' organisms in to 'unnatural' or 'novel' organisms or
- 2) as organisms that are non-organic or an anti-thesis of what is known as organic/natural or
- 3) as natural organisms that are novel but still natural in some cases as the Bt is not a synthetic organism but a naturally occurring one, used in organic agriculture.

In other words, if technology enables a hybrid that is an admixture of two naturally occurring organisms with out diminishing the essential nature of one, the hybrid could still be considered as an organic one by some.¹⁷

It can be argued that in contrast to Haraway's understanding of the separation of nature and culture in the West, nature and culture form a seamless web in Indian culture (including the culture of agriculture)¹⁸. For example, the prominent god Ganesha of the Hindus is a hybrid creation: he has an elephant's head (which can be said to symbolize nature) and a man's body (which can be said to symbolize culture). It is also possible to view Ganesha as a hybrid of two species: the elephant and the human being. Other examples of hybrid creatures that play an important role in contemporary Indian culture are Narasimha (an incarnation of the god Vishnu; Narasimha is a hybrid of a lion's head and a man's body) and matsyakanyas (mermaids, who are hybrids of women and fishes). It is certainly possible that because of this cultural background, transgenic organisms (which are "hybrid" creations of different species) are acceptable to some of those who are brought up within Indian culture. Perhaps that is the reason why several self-identified organic farmers in Gujarat can think of growing Bt cotton in their fields.¹⁹

For several readers, the blurring of agro-industrial and agro-ecological paradigms by self-identified Gujarati organic farmers may seem to be a bold and pragmatic step. Such readers need to remember that for at least fifty years, rural space has been dominated and transformed by the productionist paradigm of industrial agriculture (Thompson 1997). In this context, organic farming can be thought of as a kind of ongoing “ecological resistance movement” (Taylor, 1995), both challenging the hegemony of the agro-industrial paradigm, and exploring alternative society-nature relations (Vos 2000). According to Vos (2000), the fact that transgenic organisms could be thought to be appropriate for organic production and handling indicates the most profound kind of cognitive dissonance.

For many advocates of organic agriculture, such as Pollan (2001b), organic is nothing if not a set of values (i.e. this is better than that). Organic farming and industrial agriculture are supposed to represent antipodal sets of values. If Gujarati farmers continue to override the divide between organic farming and genetic engineering, what does it do to the meaning of “organic” and the organic movement? Is the word “organic” being gradually emptied of its meaning? Is the organic movement, which once presented a radical alternative and an often scalding critique of agribusinesses (Pollan 2001b), getting coopted by those very corporations? These are questions that we need to ask ourselves if we applaud the pragmatic orientation of Gujarati organic farmers who are adopting Bt cotton. For now, we may support the Gujarati organic farmers who are adopting unapproved varieties of Bt cotton, as they are not buying seeds from corporations. However, we need to ask ourselves if this kind of blurring of agro-industrial and the agro-ecological paradigms is both necessary and essential in order to grow enough cotton to clothe the world in the future.

Acknowledgments: This article is based on my Ph.D. dissertation (Roy 2006). I wish to gratefully acknowledge the guidance of Professor Charles C. Geisler (the chair of my Ph.D. committee) and other committee members. I would also like to express my gratitude to the Gujarati farmers who welcomed me into their homes and fields, allowed me to interview them and follow them around, and freely shared their knowledge of farming and wisdom with me.

Endnotes

- ¹ The pioneers of organic agriculture, in 1940s Britain, were concerned, above all else, about the integrity of soil. Their philosophy was centered on practices designed to improve the richness and stability of soil by restoring its organic matter and avoiding synthetic fertilizers, pesticides and herbicides. This point is important because most farmers in my sample were concerned about soil fertility and the impact of transgenic plants on soil fertility.

- ² The organic “movement” globally is a loose collection of various individuals and organizations, who differ from each other in terms of both the practice of organic agriculture and the theory behind it. For example, included in this group of organic agriculture practitioners and theorists are agroecologists, biodynamic agriculturalists, and permaculturalists, all of whom differ from each other in many important ways.
- ³ For example, the European organization IFOAM states in its position paper that it is opposed to genetic engineering in agriculture “in view of the unprecedented danger it represents for the entire biosphere and the particular economic and environmental risks it poses for organic producers (IFOAM 2004)”. The IFOAM believes that genetic engineering in agriculture causes, or may cause: negative and irreversible environmental impacts, release of organisms which have never before existed in nature, pollution of the gene pool of cultivated crops, micro-organisms, and animals, pollution of off-farm organisms, denial of free choice, both for farmers and consumers, violation of farmers’ fundamental property rights and endangerment of their economic independence, practices which are incompatible with the principles of sustainable agriculture, and unacceptable threats to human health. Therefore, the IFOAM calls for a ban on genetically modified organisms in all agriculture (not just in organic agriculture).
- ⁴ Please note that these self-identified organic farmers follow organic philosophy in their methods of cultivating cotton, but they sell their cotton under the “conventional” label in the market. These thirty self-identified organic farmers are not selling cotton labeled as “organic” in the market. They are not affiliated with any organic cotton marketing schemes and the cotton they grow is not certified as “organic.”
- ⁵ “Bt” stands for *Bacillus thuringiensis*, a bacterium discovered by Ernst Berliner in 1911. Organic gardeners and farmers have used Bt foliar spray to protect their cotton against bollworms for over fifty years now. Monsanto, a large multinational company based in the United States, used recombinant DNA technology to create Bt cotton. Monsanto released Bt cotton for commercial production in the United States in 1996. Transferring particular characteristics between species is a significant achievement. For example, scientists have taken Cry1Ac gene (which codes for a toxin that is fatal to the American bollworm *Helicoverpa armigera*, a major pest of cotton) from the soil bacterium *Bacillus thuringiensis*. They have incorporated this Cry1Ac gene into the cotton genome, to yield, the pesticide-producing Bt cotton plant. This genetically modified or genetically engineered Bt cotton plant thus manufactures its own pesticide against bollworms.
- ⁶ Users of a given technology play an important role in constructing and defining that particular technology in practice. This aspect of technology has been widely studied by sociologists of science and technology, especially those who employ the social construction of technology (SCOT) perspective. For example, early users of the automobile in America did not just use the car for transportation purposes. They used it to power their farm equipment and household machines. Another possible example is the Napster music piracy case, in which young Americans were downloading and sharing music for free. A third example is that of dhaba (roadside restaurants) owners in India using washing machines to mix their lassi (a yoghurt-based drink). Also, note that as lay users seek to define the role of a particular technology, other social groups seek to impose their own definitions of a given technology and restrict the use of a given technology. In this game of power, the users may win only in some cases. In the context of organic agriculture, which is a contested concept, different

individuals and social groups (users) of that technology seek to impose their own understandings of what “organic” means vis-à-vis “chemical” agriculture.

- 7 In the United States of America (USA), the label of “organic” means the product is free of genetically modified organisms. This is only one way of defining what is “organic,” since this particular definition of what is organic has evolved over years of debates between different users and ideologues of organic agriculture. It is possible that users and ideologues in other societies may define “organic” agriculture differently.
- 8 SRI is a controversial technology with skeptics questioning its relevance and adherents vehemently defending it. Thakur, A.K (2010) for an overview. SRI has become popular in India although it has not been officially endorsed or supported by the scientific establishment. (Prasad,S. 2009)
- 9 Pollan (2001a) takes the view that plants such as the apple, tulip, marijuana, and potato can be seen as using human agents for their own evolutionary goals, rather than vice versa.
- 10 I went back to Vadodara (Gujarat) in summer 2009 to interview the same farmers, and found that many of them held the same views about genetically modified cotton seeds. Further, some of them were continuing the practice of growing Bt cotton. Out of the 2004 sample, one farmer (Chintanbhai Patel) had retired; three farmers were not available for interviewing (Vikrambhai Patel, Chamanbhai Patel, and Amodbhai Patel), while three had stopped organic farming and turned to chemical farming (Amanbhai Patel, Sarojben Patel, and Hiteshbhai Patel). Out of Group I farmers (those who said that Bt cotton is not part of organic farming), twelve were available for interviewing (except Amodbhai Patel). All twelve still believed that Bt cotton is not part of organic farming, but only four had grown Bt cotton the previous year (2008-09). Out of Group II farmers (those who said that Bt cotton is part of organic farming), only eight could be interviewed (one farmer had retired, two were not available, and two had stopped organic farming). Out of these eight farmers, only three believed that Bt cotton is part of organic farming and the rest believed the opposite. Only three farmers in this group had grown Bt cotton the previous year (2008-09). Out of Group III farmers (those who were undecided on the issue), three still held to their 2004 views while two had changed their views. These two farmers now believed that Bt cotton is not part of organic farming. In practice, three of these farmers grew Bt cotton in 2008-09. The views of these farmers and the data collected in 2009 are discussed in a forthcoming paper.
- 11 Each interview was transcribed in full by the author, but all the fascinating details of each interview cannot be presented in this article for reasons of space. Those themes that are not directly related to the conclusions have been left out; complexity has been reduced and certain themes omitted. Also, note that “Patel” is a common last name among farmers in Gujarat. The Patel case is a major land-owning caste in Gujarat.
- 12 All farmers’ names used in this paper have been changed in order to protect their privacy; this is particularly desirable as the growing of illegal crops was common in this sample. In 2004, farmers had planted unapproved genetically modified cotton in more than half-a-million acres in Gujarat state, according to industry executives (Jayaraman 2004). The cultivation of unapproved genetically modified cotton in Gujarat is in itself an interesting story. Before the approval of any transgenic crop for planting in India, and pending results of bio-safety-mandated field trials, Bt cotton was discovered growing in farmers’ fields in Gujarat in September-October of 2001. The Government in New Delhi soon gave provisional approval, in March

2002, to Mahyco-Monsanto Biotech Ltd. To release three Bt cotton varieties under the brandname of Bollgard: India's first commercialized transgenics. From 2002-03 onwards, Gujarati farmers had a wide range of cotton choices: they could choose among the three varieties of officially approved Bollgard varieties that joined non-Bt hybrids and traditional (indigenous) varieties. Moreover, farmers could choose among a wide range of gray-market seeds: the unofficial Bt variety that had been growing unapproved and unnoticed by biosafety institutions for some years (Navbharat 151), F_2 offspring of Navbharat 151; "loose" Bt seeds sold locally without labels; new farmer crosses of Bt cotton varieties; and branded Bt cotton produced by small entrepreneurs. See Roy, Herring, and Geisler (2007) for a discussion of how Gujarati farmers responded to official seeds and loose seeds during the early years of adoption.

- ¹³ All quotes from farmers in this paper are taken from interviews that the author conducted in 2004.
- ¹⁴ When two different parent lines (whether pure lines or not) are crossed, the first generation is called F_1 . When the same seed is grown again (and in cross-pollinated crop like cotton has chances of inert breeding within the population), it is called F_2 . The same seed when grown in the third generation is called F_3 , and in the fourth generation F_4 , and so on.
- ¹⁵ Shankar X is a hybrid variety, Gujarat 21 and Gujarat 23 are indigenous varieties of cotton, and Dr. Sarju Bt is a transgenic variety of cotton. In this author's experience, a farmer in Gujarat will generally grow many varieties of cotton (see Roy, Herring, and Geisler 2007). The farmer will mix and match cotton varieties according to his needs. Most Gujarati farmers will also grow other crops besides cotton on their fields.
- ¹⁶ The Government of India gave permission to the Rasi Company to sell its transgenic cotton seed RCH-2 I in 2003-04. As a result, during the 2003-04 growing season, the farmers in Gujarat could choose between the government approved Bt varieties (three Bollgard varieties and the RCH-2 variety) and unauthorized Bt varieties.
- ¹⁷ This position does not take into account criticisms of biotechnology as a violation of integrity of an organism or life itself. For an overview of this debate and public fears on biotechnology see Hauskeller, M 2007.
- ¹⁸ I am indebted to Professor Anil Gupta (Indian Institute of Management, Ahmedabad, Gujarat, India) for sharing this observation about Indian culture with me.
- ¹⁹ It should be noted that mermaids and satyrs exist in Western mythology too, and there are interesting chimerical creatures in today's popular fiction in the West too. An analysis of the reasons as to why Indian farmers can more easily accept "hybrid" creations of different species than say American organic farmers is beyond the scope of the present study.

References

- Buck, D., C. Getz, and Guthman, J. 1997. "From Farm to Table: The Organic Vegetable Commodity Chain of Northern California." *Sociologia Ruralis*, 37(1): 3-20.
- Bunin, L.J. 2001. "Organic Cotton: The Fabric of Change." Unpublished Ph.D dissertation, University of California, Santa Cruz.
- Deutscher, I. 1966. "Words and Deeds: Social Science and Social Policy." *Social Problems*, 13(3): 235-254.
- Foster, J.B. and P. Burkett. 2000. "The Dialectic of Organic/inorganic Relations: Marx and the Hegelian Philosophy of Nature." *Organization and Environment*, 13(4): 403-425.
- Guba, E.G. and Y.S. Lincoln. 1994. "Competing Paradigms in Qualitative Research" in N.K. Denzin and Y.S. Lincoln (eds.): *Handbook of Qualitative Research*, pp. 105-117. Thousand Oaks, CA: Sage.
- Gupta, A. 1998. *Postcolonial Developments: Agriculture in the Making of Modern India*. Durham, NC: Duke University Press.
- Guthman, J. 2000. "Raising Organic: Appropriating Nature: The Codification of Grower Practices in California." *Agriculture and Human Values*, 17(3): 257-266.
- Haraway, D. 1997. *Modest Witness@ Second Millennium*. New York: Routledge.
- Herring, R. J. 2001. "Promethean Science, Pandora's Jug: Conflicts Around Genetically Engineered organisms in India." The 2001 Mary Keatinge Das Lecture, Columbia University.
- Hauskeller, M. 2007. *Biotechnology and the Integrity of Life: Taking Public Fears Seriously*. Aldershot: Ashgate,
- IFOAM. 2004. Growing Organic: Genetic Engineering versus Organic Farming. Retrieved on June 8, 2010 from http://www.ifoam.org/growing_organic/1_arguments_for_oa/environmental_benefits/ge_vs_oa
- Jayaraman, K.S. 2004. "Illegal Seeds Overtake India's Cotton Fields." *Nature Biotechnology*, 22: 1333-34.
- Latour, B. 1993 *We Have Never Been Modern*. Translated by Catherine Porter Cambridge: Harvard University Press
- Macilwain, C. 2004. "Organic: Is it the Future of Farming?." *Nature*, 428: 792-793.
- Main Cotton Research Station, Gujarat Agricultural University (GAU). 1996. Souvenir of the National Seminar on Century of Cotton in India: 1996. Surat, India: GAU.
- Mansfield, B. 2004. "Organic Views of Nature: The Debate Over organic Certification for Aquatic Animals." *Sociologia Ruralis*, 44(2): 216-232.
- Menon, M. 2003. *Organic Cotton: Re-Inventing the Wheel*. Hyderabad, India: Bookline.
- Mills, C.W. 1959. *The Sociological Imagination*. New York: Oxford University Press.
- Mills, C.W. 1963. "Methodological Consequences of the Sociology of Knowledge" in I.L. Horowitz (ed.): *Power, Politics, and People: The Collected Essays of C. Wright Mills*, pp. 453-468. New York: Oxford University Press.
- National Organic Programme: Final Rule (2000, December 21). Federal Register, 7FCR part 205, 65, 246.
- Pollan, M. 2001a. *The Botany of Desire: A Plant's Eye View of the World*. New York: Random House, Inc.
- Pollan, M. 2001b. "The Organic-industrial Complex." Boulder, CO: Daily Camera (June 3).
- Prasad, S. 2009. "Knowledge and Democracy: Fables from SRI." *Seminar*, No 597
www.india-seminar.com/2009/597/597_shambu_prasad.htm
- Rosset, P.M. and M.A. Alteiri. 1997. "Agroecology versus Input Substitution: A Fundamental Contradiction of Sustainable Agriculture." *Society and Natural Resources*, 10:283-295.

- Roy, D. 2006. "'Farming 'White Gold': Early Experiences with Genetically Engineered Cotton Production in Gujarat, India." Unpublished Ph.D. Dissertation, Ithaca, NY: Cornell University.
- Roy, D., R. Herring, and C. Geisler. 2007. "Naturalizing Transgenics: Official Seeds, Loose Seeds, and Risk in the Decision Matrix of Gujarati Cotton Farmers." *Journal of Development Studies*, 43: 158-86.
- Stone, G. 2005. "A Science of the Gray: Malthus, Marx, and the Ethics of Studying Crop Biotechnology" in L. Meskell and P. Pels (eds.): *Embedding Ethics: Shifting Boundaries of the Anthropological Profession*, pp. 197-217. Berg, Oxford.
- Taylor, B.R. 1995. "Popular Ecological Resistance and Radical Environmentalism" in Taylor, B.R. (ed.): *Ecological Resistance Movements: The Global Emergence of Radical and Popular Environmentalism*, pp.334-54. New York: State University of New York Press.
- Thakur, A.K. 2010 Critiquing SRI Criticism: beyond Scepticism with Empiricism." *Current Science*, Vol. 98 No 10 1294-1299.
- Thompson, P.B. "Agrarian Values: Their Future Place in U.S. Agriculture" in W. Lockeretz (ed.): *Visions of American Agriculture*. Ames, IA: Iowa State University Press.
- Vos, T. 2000. "Visions of the Middle Landscape: Organic Farming and the Politics of Nature." *Agriculture and Human Values*, 17:245-256.

Patenting Status of Bioremediation Technologies in United States, Europe and India: A Comparative Study

Neelima Jerath *
Deepali **

Abstract: The article studies the status of patenting and patented technologies in bioremediation. The main aim of this study was to undertake a detailed empirical and analytical examination of patenting activity in Europe, US and India in bioremediation. The study was conducted by using databases USPTO, Espacenet and India patents and focused on the number of patents granted to inventors from a country by the U.S. Patent and Trademark Office (USPTO), the European Patent Office (EPO), and the Indian Patent Office (IPO). The study also emphasized on the patents granted entity-wise, organization wise, year wise and category wise etc.

Keywords: Patents, India, US, Europe, bioremediation technologies.

Introduction

Bioremediation is a process or technology that uses biological products to reduce/remediate the concentration or toxicity of a pollutant. It commonly uses processes by which microorganisms and plants degrade contaminants in the environment. Technologies to remediate contaminated sites fall into two principal clean-up approaches: *In-situ* treatment which is always done *on-site*. *Ex-situ* treatment requires the removal of contaminated soil for treatment or land filling. *In-situ* techniques are favoured over the *ex-situ* technique due to their low cost and reduced impact on the ecosystem.¹ Different bioremediation technologies are described in Table 1.

Every year many technologies are being invented and commercialized for bioremediation; hence there is a need for a broader legal defense of these

* Executive Director, Punjab State Council for Science & Technology, Chandigarh, India.
Email: neelimakj@yahoo.co.uk

** Women Scientist, Punjab State Council for Science & Technology, Chandigarh, India.
Email: deepali.phd@rediffmail.com

inventions. Intellectual property rights are supposed to be an important incentive for protection of research and development and they are considered to be a necessary precondition for science and technology to progress. A patent granted for an invention gives a right to its holder to exclude others from commercially exploiting the protected technical invention. There is a trade-off between the disclosures of detailed information by the inventor against the guarantee of limited monopoly awarded by the Government. Claims in the patent application with broader ranges can exclude others.

Most of the countries allow patenting of genetically modified micro-organisms but a few also allow patenting of naturally occurring micro-organisms if isolated from nature for the first time and if other conditions of patentability are satisfied. For example, In United Kingdom, a microorganism can be patented, if it is not discovered previously.² In US a biologically pure culture is patentable if it meets the standard criteria for patentability.² The Indian Patent Act has no specific provision for patenting of microorganisms and microbiological processes. Before amendment (2002) in the Indian Patent Act, plants and animals in whole or in part thereof including seeds, varieties and essentially biological process for the production of plants and animals were excluded from patenting as per Section 3(j). After amendment of 2002 in the Indian Patent Act micro-organisms can be patented if they satisfy the other requirements. However, as a matter of practice microorganisms *per se* are not patentable in India, while microbiological processes are patentable as per the decision of the Kolkata High Court on 15 January, 2002 in a case filed by Dimminaco A.G. against the decision of the Controller General of Patents, Designs and Trademark. In order to meet the obligation under Trade Related aspects of Intellectual Property Rights (TRIPS),³ India is required to introduce patenting in microorganisms, which covers “methods to isolate and obtain new organisms, improve their characters, modify them and find their new and improved uses (TRIPS)”. The most important difference between the patent law of the India and developed countries is that India does not allow patenting of microorganisms that already exist in nature as the same is considered to be a discovery as per the provisions of the Section 3(d) and therefore not patentable. But many countries allow both process and product patents in regard to microbiological inventions and microorganism *per se*.

Table 1: Different Bioremediation Technologies

Technology	Basic Principle	References
Biosparging	Involves the injection of air under pressure below the water table to increase groundwater oxygen concentrations and enhance the rate of biological degradation of contaminants by naturally occurring bacteria.	Vidali, 2001.
Bioventing	Involves supply of air and nutrients through wells to contaminated soil to stimulate the indigenous bacteria. It employs low airflow rates and provides only the amount of oxygen necessary for the biodegradation while minimizing volatilization and release of contaminants to the atmosphere.	Vidali, 2001.
Bioaugmentation	Refers to the induction of contaminated soil, sediment or sludge with isolated strains or consortia or a genetically engineered variant with specific organic-compound degrading capabilities to enhance <i>in-situ</i> or <i>ex situ</i> bioremediation applications	Lens and Grotenhuis, 2005.
Biostimulation	Nutrients are added to improve native microbial activity.	Saval <i>et al.</i> , 2006.
Biosorption	Microorganisms with affinity for metal absorption are used in specific conditions; it is generally applied in liquid phase.	Saval <i>et al.</i> , 2006.
Phytoremediation	Uses various plants to degrade, extract, contain, or immobilize contaminants from soil and water.	USEPA, 2000.

The rapid advances in the past decade in different areas of bioremediation and the applicability of the findings of such research to commercial exploitation have fuelled the increase in the number of patent applications filed in this field in all countries of the world. Patents are good indicators of research and development output. However, not all patents are equally valuable. Patent analysis makes it possible to map out the trend of technological change and life cycle of a technology- growth, development, maturity and decline.

Objectives

The objectives of this article are to:

- develop outline for several bioremediation techniques

- analyze patent literature on the different bioremediation techniques and to prepare an overall scenario on the growth of patents for these techniques
- study the market trend of bioremediation
- determine the key market player for future technology development

Material and Methods

To analyze the patenting status in US, Europe and India, data was collected using databases namely USPTO, Espacenet and India patents. Bibliographic information and abstracts for the last twenty years of all the patents from 1988-2008 for US, 1973-2008 for Europe and 1971-2008 for India were collected and analyzed to generate an overall picture. The bibliographic references contain information on patent number, publication date, IPC number, inventor's name, applicant's name, inventor's country, title, etc. The patents were classified entity-wise, organization wise, year wise and category wise to analyze patenting activities in US, Europe and India. Three databases of 558 patents were developed for data analysis.

Results and Discussions

Bioremediation shows a duality of research, i.e. a discovery could simultaneously have both basic characteristics and industrial applicability. A significant amount of research suggests that IPRs facilitate the creation of a market for ideas, encourage further investment in ideas with commercial potential, and mitigate disincentives to disclose and exchange knowledge that might otherwise remain secret.⁴ Industries that must spend more time and money in research and development generally have a greater need for patent protection in order to recoup that investment.⁵ There is a good relationship between product and patents; as corporate companies are manufacturing microbial products, patenting and getting financially benefits from the sale of the products. A number of processes and products involving the addition of selected microorganisms have been patented and marketed since early days.⁶⁻⁹ Some patents are reviewed here: Bopp (1981) discloses a new strain of *Pseudomonas fluorescens* for use in the removal of chromate from waste water. Under aerobic or anaerobic conditions this bacteria reduces chromate from chromium (VI) to chromium (III) in which form the chromium will precipitate from waste water contaminated therewith (US Pat. No. 4,468,461). Another patent description was given by Van Dort and Bedard (1992) in US Pat. No.5,227,069. They described a method for the microbial dechlorination of PCBs stimulated in sediments

by the addition of brominated or iodinated biphenyls significantly reduce the health risk of the sediment PCBs. This invention is able to stimulate extensive and rapid microbial dechlorination of aged PCBs in freshwater, estuarine and marine sediments under anaerobic conditions. On the other hand, Gill (1994) described a bioremediation process for cleaning a chemical spill (US Pat. No. 5,525,139). In this invention a biologically active absorbent is generated by selecting certain plant materials, by allowing them to partially compost, by adding a percentage of dry plant material, and by inoculating the mixture with a small amount of an organic chemical. When mixed with the spilled chemical and water, this biologically active absorbent will neutralize the spill. Wickham (1995) disclosed in patent application the methods, employed a composition comprising active amounts of an enzyme mixture, *B. subtilis* and *P. fluorescens*, and a nutrient source for the biological treatment of sewage in a sewage treatment plant, of waste streams and of ponds (US Pat. No. 5,531,898). The product is normally mixed with water for about 6 to 48 hours at ambient temperature to produce an acclimated mixture and then applied to the contaminated environment. Rosen and Ghosh (2004) isolated and purified transgenic *Saccharomyces cerevisiae* yeast cell comprising a disrupted ACR3 gene and an isolated DNA sequence, comprising a promoter (US Pat. No. 7,524,669). This product is used to hyperaccumulation of heavy metals, such as As(V), As(III), Cd(II), Sb(V), Sb(III), Hg(II), and/or Pb(II), from an aqueous medium.

Global Market for Bioremediation

Remediation markets generally only develop after a country has dealt with air, water and waste management priorities.¹⁰ Global market for remediation sector is estimated to be in the range of US\$30-35.¹¹ The US, Western Europe, Japan and Australia will continue to be the dominant international markets for remediation. In a study it was found that US bioremediation market was about US\$60 million in 1990, and was US\$100 million in 1993, which reached US\$175 to \$300 million by 1995.¹² As per EPA in North America, up to \$100 billion will be spent during the next 30 years to meet new underground tank storage regulations.¹¹ While environmental market of Western Europe is around US\$227 billion and having 600,000 potentially contaminated sites, the remediation of which will cost an estimated 50 billion over an extended clean-up duration.¹¹

In many developing countries people have been ingesting water and food contaminated with various toxic pollutants which led to cancer and many other diseases. But now we have billion dollar industry (approximately US\$4 billion), which is focusing on remediation. Projected market of the different remediation technologies is described in Table 2.

Table 2: Projected Global Market for Hazardous Waste Remediation (\$million)

Technologies	2005	2006	2011
Separation	2,018.9	2,113	2,659.7
Contamination	2,710	2,845	3,882
Thermal Destruction	1,230	1,276.8	1,556.8
Chemical Treatment	1,925	1,987.2	2,340.9
Biological Treatment	1,200	1,260	1,610
Irradiation	19.3	20.1	24.7
Recycling/ Reuse	1,639	1,889.9	4,498.625
Total	10,742.2	11,392	16,572.725

Source: BCC Research as cited on <http://www.bccresearch.com/report/ENV006A.html>

Patenting Status of Bioremediation Technologies

For the fulfillment of aforesaid objectives of study, patents granted to bioremediation techniques by USPTO during 1976 to 2008 were read thoroughly and categorized as given in Table 3.

Table 3: Patents Granted to Different Bioremediation Technologies

Technologies	Patents
Bioremediation	195
Biosorption	12
Bioventing	2
Biosparging	0
Bioaugmentation	6
Biostimulation	19
Phytoremediation	11

Patenting Activity in US, Europe and India

Analysis of the data indicates that total 558 patents were found related to bioremediation technologies among US and European countries and in India. This excludes patents filed in European countries other than English. The growth of patenting activity was observed during 1988-2008 for US, 1973-2008 for Europe and 1971-2008 for India.

Patenting Activity in US

In the past 21 years total 399 patents were granted by US patent office on bioremediation, out of which maximum 9 per cent patents were granted during the year 1999 (Table 4 and Fig.1). Thereafter a gradual decrease was noted in the number of patents till 2006, while an immediate increase recorded during 2008.

Table 4: Year-wise Patents Granted by USPTO

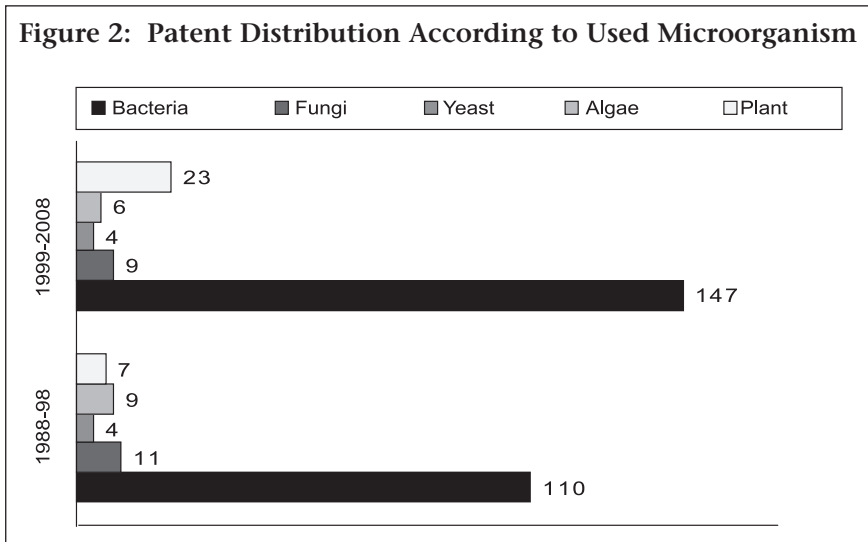
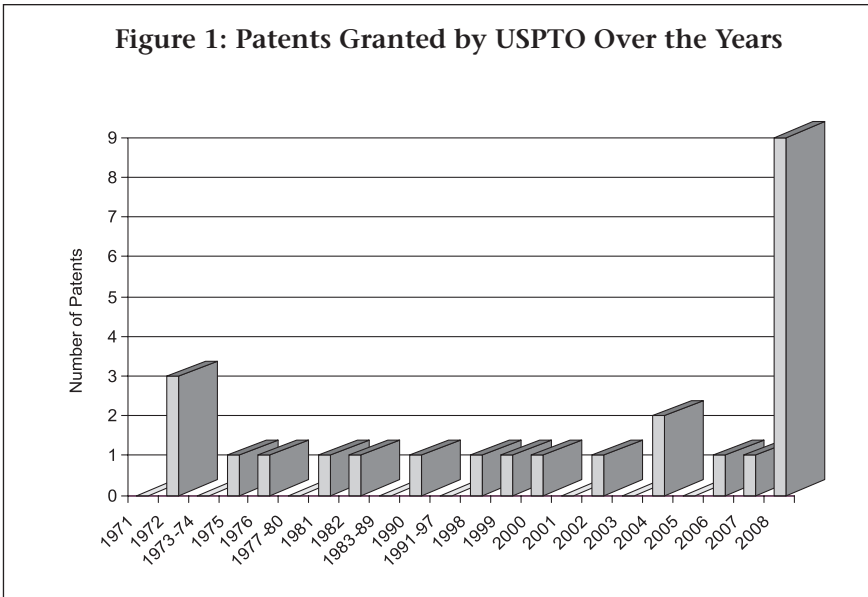
Year	Patents	Year	Patents
1988	7	1999	34
1989	6	2000	24
1990	4	2001	29
1991	8	2002	22
1992	15	2003	25
1993	11	2004	24
1994	11	2005	20
1995	19	2006	13
1996	22	2007	16
1997	28	2008	30
1998	31	-	-

A comparison of organism used for bioremediation between 1988 to 1998 and 1999 to 2008 indicates that though in both the decades 78 per cent patents release to bacteria the follows shifted from fungi (8 per cent), yeast (7 per cent) and algae (6 per cent) in the previous decade to plants (12 per cent) in the latter (Fig.2).

This trend indicates that use of bacteria for bioremediation is much higher than other organisms. Literature survey also revealed that particular interest in bacteria is because of their high cell surface area per unit volume.^{13,14} Further, generally bacteria are easier to culture and grow more quickly than fungi and other organisms.¹⁵

All USPTO patents were further categorized in five categories, i.e. American, European, Asian, Oceania and African based on area of activity of inventor. Patents granted to individual/companies based in America, Europe, Asia, Oceania and Africa were 253, 41, 20, 08 and 07, respectively, indicating that domestic patents were higher than foreign.

Out of 313 companies/institutions studied, thirty companies/institutions were found to have maximum patents in bioremediation technology. Exxon Research & Engineering Co. is the key player in US market and holds maximum number of patents (13) followed by



Geovation Technologies Inc. (11), The Regents of the University of California (8), W. R. Grace & Co. Conn. (7), Shell Oil Company (7) and The Ensign-Bickford Company (6) shown in Table 5. Companies from India have obtained only two patents (US pat no. 6,406,882 and 7,022,511)^{16,17} and contribute only 0.50 per cent, out of total 399 US patents as assignee country. These patents have been granted during 2002

and 2006 to the Council for Scientific and Industrial Research (CSIR), New Delhi. This indicates the less interest in patenting process in the field of bioremediation in Indian universities and research organization.

Table 5: Key Market Players in US

S.No.	Industry Name	Number of Patents
1.	Exxon Research & Engineering Co.	13
2.	Geobiotics, Inc.	4
3.	W. R. Grace & Co.-Conn.	7
4.	Allied-Signal Inc.	4
5.	GB Biotech Inc.	2
6.	H.sub.2 O Chemists, Inc.	2
7.	Metallurgical and Biological Extraction Systems, Inc.	2
8.	BioNutraTech, Inc.	3
9.	Cytec Technology Corp.	4
10.	Canon Kabushiki Kaisha	3
11.	General Motors Corporation	3
12.	The Ensign-Bickford Company	6
13.	MFM Environmental Co.	2
14.	General Electric Company	3
15.	Environmental Science & Engineering, Inc.	2
16.	Chevron Research & Technology Company	2
17.	Bayer Aktiengesellschaft	2
18.	Osprey Biotechnics Inc.	2
19.	Matrix Environmental Technologies	2
20.	Halliburton Energy Services, Inc.	2
21.	Geovation Technologies Inc.	11
22.	Water Research commission	5
23.	Shell oil company	7
24.	The reagents of the University of California	8
25.	University of Georgia Research Foundation Inc.	3
26.	University of Florida	3
27.	Remeiation Technologies Inc.	3
28.	Ohio University	2
29.	Gannett Fleming Inc.	2
30.	Aquafiber Technologies Corporation	2

A study of available scientific literature on the subject indicates that government funding for research in the area is generally low and industry funding for research substantially exceeds that of government. This includes funding by industry for research in universities also.¹⁸

Patenting Activity in Europe

European patent office granted a total number of 98 patents for bioremediation process in which maximum 12 patents were granted during 2008 (Table 6 and Fig.3). Out of these, the share of industries is maximum (49), followed by Universities & Research Institutes (24) and individuals (25).

Table 6: Patents Granted by European Patent Office

Year	Patents	Year	Patents
1973	1	1993	2
1974	0	1994	0
1975	0	1995	0
1976	1	1996	3
1977	0	1997	3
1978	0	1998	4
1979	1	1999	9
1980-84	0	2000	3
1985	2	2001	8
1986	1	2002	6
1987	0	2003	9
1988	1	2004	6
1989	1	2005	6
1990	1	2006	4
1991	1	2007	11
1992	2	2008	12

Amongst types of microorganism used, bioremediation through bacteria leads with 25 patents followed by plants (8), fungi (5), algae (2) and yeast (2) (See Fig. 2). Micro - organism was not specified in 56 patents. Analysis of patents showed that 67 patents were granted for bioremediation of metals; while other patents were related to bioremediation of hydrocarbons, pesticides, herbicides and other inorganic compounds.

Country-wise distribution studies indicated that European countries held maximum number of patents (36) in EPO, while American, Asian and Oceania (Australia) got 33, 27 and 02 patents, respectively. Another interesting observation in Europe was that universities lead over companies/individuals. Univ. of De Chile, Biotechnologias Del Agua Ltda is the key player in Europe and holds maximum number of patents (4) followed by Hartmeir Winfried Prof DR ING (2) and Hitachi Plant Engineering & Construction Company (2) presented in Table 7.

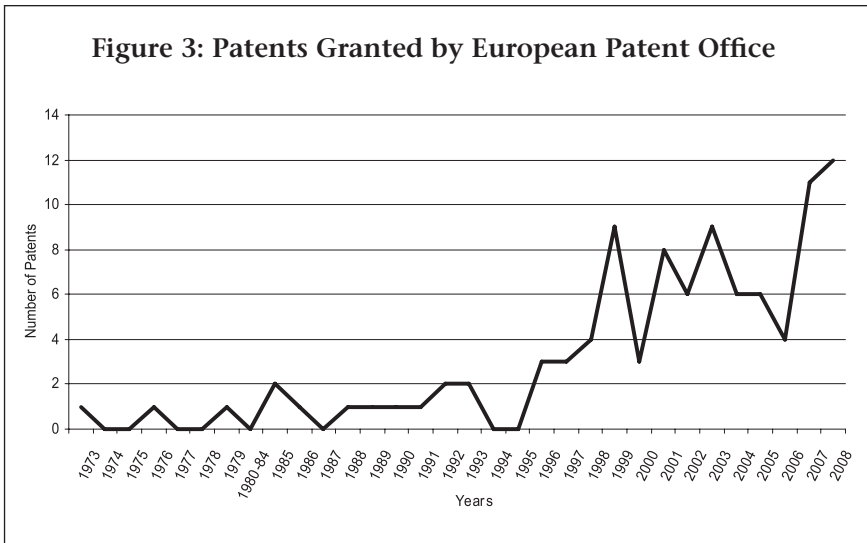


Table 7: Key Market Players in Europe

S. No.	Industry name	Patents
1.	Univ of De Chile, Biotechnologias Del Agua Ltda	4
2.	Hartmeir Winfried Prof DR ING	2
3.	Hitachi Plant Eng & Constr Co.	2

Patenting Activity in India

In India, 25 patents have been granted by the IPO in the area of bioremediation during 1971 to 2008. Maximum number of patents were granted during 2008 (9) constituting 36 per cent of total granted patents followed by 1972 (3) and 2004 (2). It clearly indicates that the Indian Universities and Research organizations are being aware for the protection of their invention (Table 8. and Fig.4).

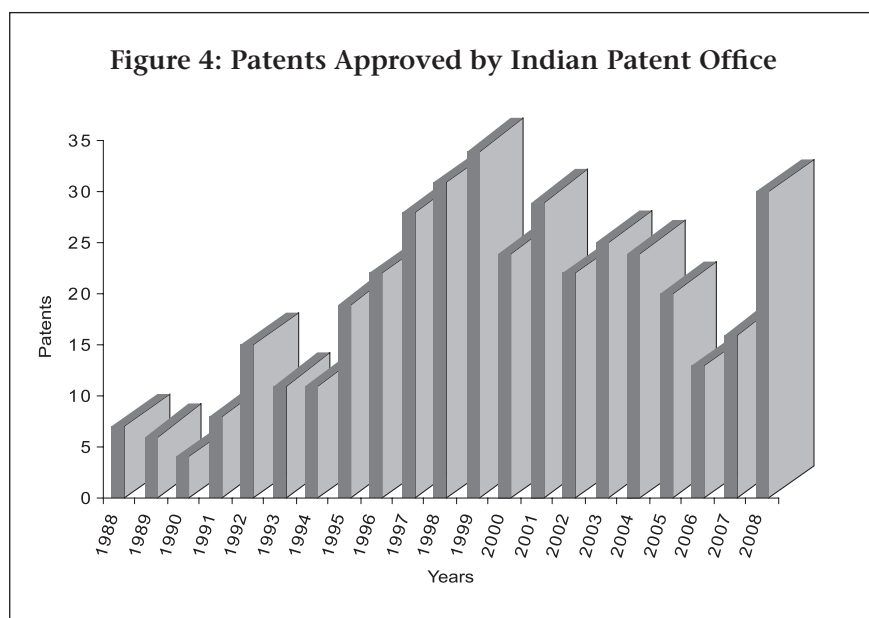
Table 8: Patents Approved by Indian Patent Office

Year	Patents	Year	Patents
1971	0	1998	1
1972	3	1999	1
1973-74	0	2000	1
1975	1	2001	0
1976	1	2002	1
1977-80	0	2003	0

Table 8 continued

Table 8 continued

1981	1	2004	2
1982	1	2005	0
1983-89	0	2006	1
1990	1	2007	1
1991-97	0	2008	9



Out of these 25 patents, maximum patents (42 per cent) were granted to bioremediation technologies using bacteria, followed by fungi (14 per cent), plants (4 per cent) and algae (4 per cent). However, in many patents (36 per cent), microorganisms were not specified (Table 9).

Table 9: Distribution of Patents According to Microorganisms

S.No.	Microorganism	Patents
1.	Bacteria	12
2.	Fungi	04
3.	Yeast	00
4.	Plant	01
5.	Not specified	10
6.	Algae	01

Analysis showed that maximum patents were granted to CSIR (41.5 per cent) followed by Southern Petrochem as given in Table 10.

Table 10: Key Players in India

S.No.	Applicants	Patents / Applications filed
1.	CSIR	05
2.	Southern Petrochem	02
3.	ICAR	01

Further, against only 10 Indian patent holders, foreign patent holders were 15, indicating lower level of domestic patenting and/or research activity. A positive feature of patenting in the IPO was the involvement of Indian universities in the patenting process. Maximum patents in IPO were granted to Universities and Research organizations.

The whole study indicates that generally a “home bias” is reflected in patent data especially in the developed countries and inventors tend to prefer domestic patent offices to foreign ones. Similar observation was made by Criscuolo (2006) also. Companies tend to apply for patents first in their domestic patent office and seek foreign patents only for their most significant and valuable products and processes. The United States continues to have a dominant share, on both domestic as well as foreign patents.

Conclusions

From the above discussion it can be concluded that with the advancement of cleaner technologies, products related to environmental protection are becoming the area of interest in numerous industries. But still there is a need to create an awareness about the benefits of patenting and also there should be practice of licensing for bioremediation technologies because a non-corporate entity like university, research institution, and hospital may lack capital to develop viable products from its discovery. Licensing the technology allows these entities to get profit from their intellectual efforts.¹⁹ Licensing may facilitate the commercialization of technologies especially in developing nations.

Acknowledgements: The authors are thankful to DST-TIFAC for financial support under Women Scientist Scholarship Scheme (WOS-C) and Patent Information Centre at Punjab State Council for Science & Technology, Chandigarh for access to patent databases.

Endnotes

1. Burns *et al.*, 1996.
2. Sekar, 2002.
3. TRIPS.
4. Arora *et al.*, 2001.
5. Burk and Lemley, 2009.
6. Varadaraj *et al.*, 1994.
7. Coschigano, 1999.

8. Cline, 1999.
9. Trauger *et al.*, 2008.
10. Naidu, 2007.
11. Singh and Ward, 2009.
12. www.molecular-plant-biotechnology.info assessed 03.03.2010.
13. Gutnick and Bach, 2000.
14. Mameri *et al.*, 1999.
15. Glazer, 1997.
16. US Pat. No. 6,406,882.
17. US Pat. No. 7,022,511.
18. Bera, 2009.
19. Michelin, 1997.

References

- Arora, A., Fosfuri, A. and A. Gambardella. 2001. *Markets for Technology: Economics of Innovation and Corporate Strategy*. Cambridge: MIT Press.
- BCC Research. <http://www.bccresearch.com/report/ENV006A.html>
- Bera, R.K. 2009. "The Changing Role of Universities and Research Institutions in a Global Economy: Lessons Drawn from the US Biotechnology Sector". *Current Science*, 96 (6) (March): 774-778.
- Bopp, L.H. 1981. US Patent No. 4,468,461. Microbiological Removal of Chromate from Contaminated Waste Water. General Electric Company (Schenectady, NY).
- Burk, D.L. and M.A. Lemley 2009. "Courts and the Patent System". *Regulation*: summer, pp.18-23.
- Burns, R.G., Rogers, S. and I. McGhee 1996. "Remediation of Inorganics and Organics in Industrial and Urban Contaminated Soil" in R Naidu, R.S. Kookana, D.P. Oliver, S. Rogers and M.J. McLaughlin (eds): *Contaminants and the Soil Environment in the Australasia-Pacific Region*. London: Kluwer Academic Publishers. Pp. 125-181.
- Cline, K.K. 1999. US Patent No. 6,248,234. Water-dissolvable Bioremediation Device and Method of Use.
- Coschigano, P.W. 1999. US Patent No. 6,395,539. Composition and Methods for Bioremediation, Ohio University (Athens, OH).
- Crisuolo, P. 2006. "The 'Home Advantage' Effect and Patent Families. A Comparison of OECD Triadic Patents, the USPTO and the EPO". *Scientometrics*, 66: 23-41.
- Gill, P.E. 1994. US Pat. No. 5,525,139, Process for Bioremediation of Soils.
- Glazer, A.N. 1997. *Microbial Biotechnology*. New York WH Freeman and Company. Pp. 54-58.
- Gutnick, D.L. and H. Bach 2000. "Engineering Bacterial Polymers for the Bio-sorption of Heavy Metals, New Products and Novel Formulations". *Applied Journal of Microbiology and Biotechnology*, 54 (4): 451-460.
- Kumar, R. and A. Kumar 2003. US Pat. No. 7,022,511. Process for the Isolation and Acclimatization of Bacteria for Lignin Degradation. Council of Scientific & Industrial Research (New Delhi, India).
- Kumar, R., Sharma, A. and A. Kumar 2000. US Pat. No. 6,406,882. Immobilized Microbial Consortium for the Treatment of Phenolic Waste-water from Petroleum Refineries. Council for Scientific and Industrial Research (New Delhi, India).
- Lens, P. and T. Grotenhuis 2005. *Soil and Sediment Remediation: Mechanisms, Technologies and Applications*. IWA Publishing. Pp. 523.
- Mameri, N., Boudries, N. and L. Addour 1999. "Batch Zinc Bio-sorption by a Bacterial Non-living *Streptomyces rimosus* Biomass". *Water Research*, 33 (6): 1347-1354.
- Michelin, R. 1997. "Licensing in Biotechnology". *Le Journal*, 29:17-15.
- Naidu, R 2007. National Media Briefing. "The Contaminated Society – Australia's Hazardous Waste Legacy". Australian Science Media Centre. June. Pp.1-2.

- Rosen, B. and M. Ghosh 2004. US Pat. No. 7,524,669. Transgenic *Saccharomyces cerevisiae* and Method for Bioremediation. Wayne State University (Detroit, MI).
- Saval, S., Terzic, J.S. and M.M. Vrvic 2006. "Bioremediation of Contaminated Soils and Aquifers". *Mikrobiologija*, 43(2): 65-76.
- Sekar, S. 2002. "Patenting Microorganisms: Towards Creating a Policy Framework". *Journal of Intellectual Property Rights*, 7(3): 211-221.
- Singh, A. and O.P. Ward 2009. "Biological Remediation of Soil: An Overview of Global Market and Available Technologies" in Singh, A., Kuhad, R.C. and Ward, O.P. (eds): *Advances in Applied Bioremediation*. Soil Biology. Pp 17.
- Trauger, R.J., Olsta, J.T., Hornaday, C.J., Darlington, J. and W. Jerald 2005. US Patent No. 7,419,593. Bioremediation Mat and Method of Manufacture and Use. AMCOL International Corp. (Arlington Heights, IL).
- USEPA February, 2000. Introduction to Phytoremediation. National Risk Management Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268. EPA/600/R-99/107.
- Van Dort, H.M. and D.L. Bedard 1992. US Pat. No. 5,227,069. Bioremediation Method, General Electric Company (Schenectady, NY).
- Varadaraj, R. Bock J. and M.L. Robbins 1994. US Patent No. 5,436,160. Bioremediation of Hydrocarbon Contaminated Soil. Exxon Research & Engineering Co. (Florham Park, NJ).
- Vidali, M. 2001. "Bioremediation. An Overview". *Pure Applied Chemistry*, 73 (7):1163–1172.
- Wickham, D.E. 1995. US Pat. No. 5,531,898, Sewage and Contamination Remediation and Materials for Affecting Same". International Organic Solutions Corp. (Mill Valley, CA).
- www.espacenet.com
- www.indianpatents.com
- www.molecular-plant-biotechnology.info assessed 03.03.2010.
- www.uspto.gov.in
- www.wipo.int

Book Review

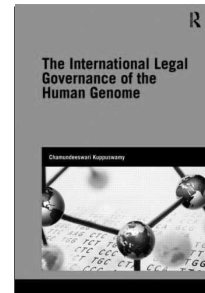
The International Legal Governance of the Human Genome

Chamundeewari Kuppaswamy. London: Routledge. 2009.
Pp: 210 ISBN: 978-0-415-45857-3 (hardback) 978-0-203-92940-7 (electronic)

The book provides an interesting reading of the gamut of ethical, legal and social issues arising out of the path breaking research on human genome, especially on account of property rights and of the international legal regime governing the research. International law based on human rights law has already been used to regulate the biotechnology research for the past few decades. However, the author argues in the book that if the human rights framework is to be used meaningfully in the human genome project, it has to be based on a unified theory of human rights where the distinction between positive and negative rights does not exist and proposes a Common Heritage of Mankind (CHM) approach with Right to Development (RTD) at its core in conducting the regulation of research on human genome. The book contains six chapters dealing with the issues of bioethics, CHM in international law, RTD and intellectual property rights.

The Human Genome Project (HGP), a symbol of scientific and technological advancement in the 21st century, has raised new concerns on the exacerbation of inequalities in the society. Inequalities between the rich and poor, the developing and developed states and the healthy and unhealthy are some of the major issues haunting the governance of the scientific research. With so much hope being placed on the HGP to health benefits, the concerns on acceleration on inequalities in health care are not completely unfounded. A number of international organizations including bodies of United Nations and European Union have been engaged in the development of international law, based on human rights law, to regulate biotechnology research in the past few decades.

The Nuremberg Code has been the pioneering international instrument in regulating the medical research. The informed consent, no-harm, benefit to society and minimum standards for experimentation principles of the Code can now be found in international and national



law and policy. Though the Code could have provided the starting point on the international engagement on ethics in medical research, this has not been the case primarily on account of two reasons. One, the Code was considered 'a good code for barbarians and an unnecessary code for ordinary physicians', and two, UNESCO despite being mandated to promote science for human welfare did not actively promote the Code in the conduct of the medical research. The ELSI programme concerning the research into ethical, legal and social issues as part of HGP also failed in addressing the critical issues emerging out of human genome research. Major drawback has been that it does not probe the ethical concerns about inequalities in access to such research at the global level. One very important such issue is the property rights in the human genome. The property rights granted to products derived from human tissue benefits the inventors and investors and no benefit accrues to the owner of the human tissue. If the tissue is being provided by an indigenous group and the researcher goes on acquiring patents over the products derived out of the tissue and no benefit is shared with the owner of the tissue, the situation becomes problematic. The emerging new technologies pose challenges not only to civil and political rights but also to the economic, social and cultural rights; but more to the latter. In order to address the challenges raised by the human genome project, the legal governance of the human genome will be effective only if a unified theory of civil and political rights and economic, social and cultural rights is adopted.

The 1997 Universal Declaration on Human Genome and Human Rights adopted by the General Assembly was the first international instrument to govern the human genome, embodying a CHM framework. The key elements of the CHM regime are non-appropriation, international management, benefit sharing and peaceful use. It reiterated a number of rights notably right against discrimination and right to health. However, the Special Rapporteur appointed by the Sub-Commission on the Promotion and Protection of Human Rights in 2002 to study the issue of human rights and bioethics did not endorse the CHM based regime. This is because of the apprehension that it would affect the growth of science. The deep seabed mining is seen to have been hampered due to the CHM regime. Author argues that the Universal Declaration provides only an outline of the CHM approach and it can be modified and improved to suit the challenges raised by the human genome research. The case of plant genetic resources is cited to show that CHM models are not static. The plant genetic resources were declared CHM in the early 1980s which had been modified after the

adoption of CBD in 1992. Thus, the book makes a very strong case for exploring the different models of international law before abandoning the concept altogether.

The benefit sharing provisions contained in the 1997 Universal Declaration are actually limited by the notion of human dignity and RTD. In the context of human genome, RTD is centered on right to health. According to Gewirthian human rights theory, right to health can be identified as a right wherein the responsibility for the fulfillment of such a right is restricted to achievable goals. This theory which lays the emphasis on action argues that inability of a person to be able to act is a violation of human dignity. In order to fulfill the chosen purpose, the individual needs to be empowered with the basic ability to act. This ability to act is a basic need-generic need and these basic needs can be met through a variety of means. These needs correspond to genetic rights. The concept of generic rights recognises positive and negative rights and incorporates the notion of solidarity. Solidarity involves a notion of responsibility that does not directly correlate to duties. It also constructs a hierarchy of rights consisting of basic well-being, which is fulfillment of basic generic needs and freedom which is a condition which enables choice of action. It creates a hierarchy based on generic needs. Gewirth also highlighted the right to productive agency to fulfill basic generic needs. In International law, productive agency is similar to RTD. The declaration on RTD (1986) and the Vienna Declaration and Programme of Action (1993) placed RTD highest in the hierarchy of human rights. The Independent Expert on RTD identified action plan for three rights - food, health and education - and recommended formation of development compacts for achieving minimum levels of human security. In a similar way, the Universal Declaration on Bioethics and Human Rights, adopted by UNESCO in 2005 and read together with the CHM provisions of the 1997 Universal Declaration, emerges as a framework within which health can be included.

The main criticism against CHM in human genome is that it is preventing the grant of IPRs in genomic research. CHM models such as the Law of Sea do not preclude grant of monopoly but provide a property model different from current models on property rights. This model seeks to reconcile the conflict between the monopoly power and the fulfillment of rights of those who cannot engage in the sharing of power arising out of such property rights.

On the whole, this book brings out very succinctly the economic, social and legal issues associated with human genome research especially

in health care. The author has used a very reader friendly language. And wherever necessary the author goes to history in a delicate manner so that both the layman to the issues related to HGP and those who are familiar with these issues will find the book worth reading.

— **Reji K. Joseph,**
Consultant, RIS.
rejikjoseph@ris.org.in

Asian Biotechnology and Development Review (ABDR)

ORDER FORM

For subscribers in India, Other Developing Countries and Rest of the World

	Annual		Single Issues	
	Institutional	Individual	Institutional	Individual
India	<input type="checkbox"/> Rs. 800	<input type="checkbox"/> Rs. 500	<input type="checkbox"/> Rs. 400	<input type="checkbox"/> Rs. 250
Other Developing Countries	<input type="checkbox"/> US\$ 60	<input type="checkbox"/> US\$ 30	<input type="checkbox"/> US\$ 30	<input type="checkbox"/> US\$ 15
Rest of the World	<input type="checkbox"/> US\$ 95	<input type="checkbox"/> US\$ 45	<input type="checkbox"/> US\$ 48	<input type="checkbox"/> US\$ 23

Tick as appropriate

- I/we would like to subscribe to **Asian Biotechnology and Development Review** and my payment instructions are given below.
- I/We would not like to receive **ABDR**.
- I/We would like to receive **ABDR** but am unable to pay the subscription charges.

Name: _____

Company/Institution: _____

Address: _____

City: _____ State/Province: _____

Zip/Postal Code: _____

Country: _____ e-mail: _____

Subscription Total: US\$ / Rs.

Method of Payment

- Purchase order enclosed
- Bill me. Phone Number required

Phone: _____ Signature: _____

Send your order to Publication Officer along with the DD drawn in favour of Research and Information System and payable at New Delhi.



RIS

**Research and Information System
for Developing Countries**

Core 4 B, Fourth Floor, India Habitat Centre

Lodhi Road, New Delhi - 110 003 (INDIA)

Tel.: 91-11-24682177/80 Fax: 91-11-24682173/74

Email: publication@ris.org.in Website: www.ris.org.in