The Role of the National Innovation Systems Framework in Facilitating Socio-Economic Development in Burkina Faso: Model and Policy Practice

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Abstract

Since the 1960s the government of Burkina Faso has consistently sought to implement new development policies to improve the economic and social conditions of its people. Until the end of the 1990s these efforts have been disappointing and unsatisfactory. In the early 2000s there was a shift towards a knowledge-centred development policy and policy makers trusted that it would bring about the sough-after improvements. In 2006 Burkina Faso chose to adopt the National Innovation Systems (NIS) framework as a policy tool to implement this new policy.

Drawing on a broader definition of technology that covers social technologies, this thesis used the ST-Systems analytical concept to chart the adoption and diffusion of the NIS policy tool at two levels, namely at strategic policy level and at the operational level, focusing here on the case of Bt cotton which was officially introduced to Burkina Faso in 2003.

Ethnographic methods, including in-depth interviews with policy makers, farmers, Monsanto representatives, civil society actors and researchers, were used to gain new insights into the difficulties encountered by these actors when trying to implement the NIS policy tool. 60 interviews were analyzed against a backdrop of detailed historical studies, based on examining a large amount of grey literature, published between 1961 and 2016.

Findings show that the implementation of the NIS policy for innovation diffusion for socio-economic development in Burkina Faso was shaped by local actors competing for control of financial resources and power positions. The new tool also had to

compete with older, more familiar tools. In the end, it failed to bring about the expected improvements in policy design and practice at sectoral level.

The thesis is among the first to have studied empirically the transfer processes of the NIS policy tool for innovation diffusion in an African country (Burkina Faso) through a case study focusing on the introduction of Bt cotton. The results achieved should contribute to more informed development policy-making in Burkina Faso.

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List of Acronyms

AAB: African Agency of Biotechnology

ABNE: Africa Biosafety Network of Expertise

ACC: Colonial Cotton Association

AIC-B Inter-Professional Cotton Association

AMCOST: African Ministerial Council on Science and Technology

ANT: Actor Network Theory

ANVAR: National Agency for Valuing Research Results

AU: African Union

AVV: Volta Extended Land

BBA: Burkina Biotech Association

CAC: Codex Alimentarius Commission

CBD: Convention of Biological Diversity

CEN-SAD: Community of Sahel-Saharan State

Bt: Bacillus Thuringiensis

BUMUGEB: Office of Mines and Geology in Burkina

CES: Economic and Social Council

CFA: Currency for French Colonies

CFDT: French Fibre Company

CITEC: The Textiles Cotton Industry

CNSF: National Research Centre for Forest Seeds

CNRST: National Centre for Scientific and Technological Research

CORAF : Conseil Ouest et Centre africain pour la Recherche et le développement agricoles

CIRAD: Centre for Internationale Cooperation Research and Agronomics

CVRS: Voltaic Centre of Scientific Research

DONATA: Dissemination of New Agricultural Technologies in Africa

ECOWAS: Economic Community of West African States

ESD : Ecole supérieure de droit

ESI : Ecole supérieure d'informatique

ESSEC : Ecole supérieure des sciences économiques

ESSSA : Ecole supérieure des sciences de la santé

EU : European Union

FARA : Forum pour la Recherche Agricole en Afrique

FAO: Food and Agriculture Organization of the United Nations

FEPPASSI : Fédération des Professionnels producteurs Agricoles de la Sissili

FDI : International Development Fund

FONER : Fond National pour L'Education et la Recherche

FRSIT : Forum National de la Recherche Scientifique et des Innovations Technologiques

GDP: Gross Domestic Product

GM: Genetically Modified

GMO: Genetically Modified Organism

GNP: Gross National Product

GPC: Cotton Producer Groups

GV: village teams

IAR4D: Integrated Agricultural Research for Development

IDR: Institute for Rural Development

IDRC: International Development Research Centre

IFIAS: International Federation of Institutes for Advance Studies

IFAN: French Institute of Black Africa

IMF : International Monetary Fund

IMP : Institut de mathématique et de physique

INAFEC : Institut national de formation et des études cinématographiques

INERA: Institute of Environment and Agricultural Research

INC : Institut national de chimie

INSE : Institut des sciences de l'éducation

INSS: National Institute of Social Sciences

INSHUS : Institut des sciences humaines et sociales

INSULLA : Institut supérieur des lettres, des langues et des arts

IPR: Intellectual Property Right

IRAT: Experts from the Institute of Agronomic and Tropical Research

IRCT: Institute of Research on Cotton and Textiles

IRSAT: Institute of Research in Applied Sciences and Technology

IRSS: Institute for Research in Health Sciences

ISAAA: International Service for the Acquisition of Agri-biotech Applications

ISN: Institut des sciences naturelles

KMA: Knowledge Management for Africa

MAP: Multi-Actors Platform

MESS: Ministry of Secondary and High School

MESSRS: Ministry of Secondary, High School and Scientific Research

MRSI: Ministry of Scientific Research and Innovation

NEPAD: New Partnership for Africa’s Development

NIS: National Innovation Systems

OECD: Organisation for Economic Co-operation and Development

OFOT: Organization of French Overseas Territories

ORD : Regional Development Organisation

PAPEME : Programme d’Appui aux Petites et Moyennes Entreprises

R&D : Research and Development

SCADD : Stratégie de Croissance Accélérée et de Développement Durable

SAP: Structural Adjustment Programs

SAPA: Structural Adjustment Program in Agriculture

SCOT: Social Construction of Technology

SNII: Salon of Inventors and Innovators

SOCOMA : Société Cotonnière du Gourma

SOFITEX : Société Burkinabè des Fibres Textiles

STS: Science and Technology Studies

ST-Systems: Socio-Technical Systems

TENs: Techno Economic Networks

TEP: Technology Economy Program

UCEF : Union Cotonnière de l’Empire Française

UEMOA : Union Economique et Monétaire Ouest Africaine

UNDP: United Nations Development Programme

UNESCO: United Nation Educational Scientific and Cultural Organization

UNPCB: National Union of Cotton Producers in Burkina

VOLTEX: The Voltaic Textiles

WB: World Bank

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Chapter 1: General Introduction

1.1 What is this Research About?

Burkina Faso is a country that achieved independence from France in 1960. It has been keen to develop its science and industry base for the last 20 years, specially its cotton industry. Various policies and frameworks have been used to stimulate growth in science and industry. Amongst them there is the most recent policy tool rooted in a concept called National Innovation Systems (NIS). This thesis takes Burkina Faso and its cotton industry as a case study to investigate the implementation of the NIS as a policy tool. In doing so it also examines how the concept of NIS has been used and adopted in various contexts and how it came to be used in Burkina Faso. It is a methodological requirement that justified the here study of the NIS at both strategic and operational levels along the policy continuum. The ST-Systems, a key analytical concept in Science and Technology Studies (STS) is the theoretical lens through which all this is examined. Methodologically, the thesis is based in ethnography, in particular on in-depth interviews with almost all key stakeholders involved in trying to use the NIS as a policy tool in Burkina Faso and with those trying to innovate the Bt cotton industry in this context.

In the following sections, I shall first provide an overview of the NIS framework emergence and its use in different contexts and by different actors. Second, my research objectives and research questions will be made explicit. Third, I will justify the importance of the present study and finally, the methodology and the structure of the thesis will be stated.

1.1.1 The Emergence of the National Innovation Systems Framework

Since the Organisation for Economic Co-operation and Development (OECD)'s landmark publication on *Managing National Innovation Systems* in 1999, the framework known as National Innovation Systems (NIS) has become increasingly popular. It was first developed as a theory, concept, and analytical perspective used to study the flow of technology and information among people, enterprises and institutions. The move to this theory represented a divergence from earlier ones which were characteristically linear. It was often through such linear theories that the process of economic growth was studied, and these theories typically viewed innovation as dependent upon scientific discoveries, followed by their application. The first version, according to Godin (2009), was called the Science-Push (Godin, 2009), and was soon followed by another, known as Demand-Pull. These theories included demand, R&D, production, construction and sales, (Manley, 2003; Godin, 2009). Use of these linear theories was predominant during the 1950s, 1960s, and early 1970s.

By contrast, the first systemic theory, called 'chain linked model', focused on the inter-relationship between basic science, marketing, manufacturing and Research and Development (R&D) (Manley, 2003; Godin, 2009). Innovation was seen in this respect as an interactive and complex process.

The National Innovation Systems theory and concept was first developed in the 1980s by Freeman (1982) and Lundvall (1985) to explain technological innovation as the result of the complex interaction between institutions (Lundvall, 2007). This conceptual framework began to be adopted in Science, Technology and Innovation

Studies in the 1990s to study innovation systems (Nelson, 1993; Freeman, 1995; Lundvall, 1992; Lundvall, 2007). Godin (2009) has shown that the 'system approach' developed thanks partly to the contribution of the Organisation for Economic Co-operation and Development (OECD) in this area and its very early work from the 1960s.

In overall terms, the National Innovation Systemss theory stresses that the flows of technology and information among people, enterprises and institutions are key to the innovative process. Thus, innovation and technology development are the result of a complex set of relationships among actors in the system, which includes enterprises, universities and government research institutes (Godin, 2009). The inclusion of the country's research system in this complex set of relationships is another distinctive element of this approach. Godin notes that

> The National Innovation System framework [theory] suggests that the research system's ultimate goal is innovation, and that the system is part of a larger system composed of sectors such as government, university, and industry and their environment. The framework also emphasized the relationships between the components or sectors, as the 'cause' explaining the performance of innovation systems. (Godin 2009: 476-477)

Such a theory rests on the premise that understanding the linkages among the actors involved in innovation is the key to improving technological performance. Innovation and technical progress are the result of a complex set of relationships among actors producing, distributing and applying various kinds of knowledge (OECD, 1997). McKelvey (1998) sees it as a new way of doing things, or one which involves redesigning an existing product for a niche market, or changing how work is carried out in an organisation (OECD, 1997). The NIS concept also relates two main categories – market and non-market institutions (Manley, 2003). Both are considered together in their potential to influence the direction and speed of innovation and technology diffusion in a country (OECD, 1997).

It is important to note that this NIS theory developed principally from the study of the innovation systems of developed countries (Freeman 1987; OECD, 1999). In this connection, as Sharif puts it, "the national system of innovation is taken to be the totality of institutions and practices that interact to produce and diffuse new technology" (Sharif 2006:84). Here the NIS is considered as an object of study in the sense of appellation of British NIS, America NIS, Burkina Faso NIS etc. to refer to a SYSTEM that one can study as an OBJECT. It is as Freeman, put it "…the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies" (Freeman, 1987 in OECD, 1999:10).

During the 1990s and 2000s, the importance of the innovation system in relation to new technology was widely accepted and its use began to spread in developed and developing countries (OECD, 1999). In addition, the importance of knowledge in the process of innovation diffusion has become an object of significant attention. As a result, knowledge has been identified as a driver (OECD, 1997; 1999) for achieving and enhancing sustainable economic growth. This contemporary view has been widely adopted (OECD, 2005) and has had a significant impact on innovation strategy and policy, particularly in developed countries. The contributions of the individual institutions are not considered in isolation but with "how they inter-act with each other as elements of a collective system of knowledge creation and use, and on their interplay with social institutions (e.g., values, norms, legal frameworks)" (Smith in OECD, 1999: 24). In this interaction, the government can play a key role through its policy options and regulations. Innovation system approaches, underpinned by framing assumptions and conventions formed in relation to developed countries' experiences, came to be applied in developing countries without much in the way of modification in relation to the different context.

Later the NIS is also used as a policy tool or model used to steer national innovation systems. The government's interest in NIS policy tool is particularly useful for this thesis, as it points to a third definition of the framework where, in relation to policy circle, NIS is viewed as a 'policy tool' (Lundvall 2007:1) which gives a practical coherence to policy makers to design and implement their policies. It can be considered as a policy narrative through which policy makers frame their policies. Godin clearly captures this aspect when he says that "Policy-makers construct their problem through conceptual frameworks that structure policy action". (Godin 2009:5). It is in this respect that the NIS can be considered as a model, that is "a technology that allows us to […] make things work in the world" (Morrison and Morgan 1999:32). In the framework of this thesis, it is this dimension (NIS framework use as a policy tool in Burkina Faso, and sectoral development strategy) that is being investigated. In the specific case of Burkina Faso, a project was developed in 2006 by both the FRSIT (representing the government) and the IRDC which was intended to introduce the NIS framework as a policy narrative in order to improve what one might call the NIS of the country.

1.1.2 Burkina Faso and Innovation Policy

Burkina Faso, like a number of post-colonialist African states, sought to develop its economic base, especially in relation to agriculture. It recognised the importance of science and innovation at an early stage, and sought to boost development using institutional methods as well as market-based approaches.

By the end of the 1980s, awareness of the place and role of science in development was being shaped through key policy debates and documents. The Symposium of Faracoba, the very first systematic review of scientific ambition and potential in the history of the country since independence in 1960, set out to ensure: 1) more independence in conducting and organising research; 2) the effective linking of all research programmes to social and contextual realities and needs; and 3) the linking of research activities to productivity (CNRST, 1987). The symposium's strategy was to "make scientific research serve the real interests of society" (CNRST, 1987:4). In the early 1990s, a further political step was taken in line with this which consisted in the creation, by the decree n° 95-347/PRES/MESSRS on the 19th September 1995, of the National Forum for Scientific Research and Technological Innovation (FRSIT) (MESSRS, 2010). The FRSIT was created by the Burkina Faso government with two main objectives[1]: 1) to value and promote research and technological innovation in order to increase interest from partners and funding bodies at national and international level in national research; 2) to establish a strong relationship between researchers and other actors in technological innovation. Concomitantly, a Strategic Plan for Scientific Research was developed to implement this emerging vision of

[1] At its creation the FIRSIT set out to achieve these objectives: 1) to value (valorise) and disseminate results from research undertaken in Burkina Faso by national researchers or those doing research for the country but based outside the country 2) to promote technological innovation 3) to promote research and endogenous technological inventions. 4) to increase the interest of national and international communities in the research programme of Burkina Faso 5) to interest research partners and promote technology and diffuse research findings and results 6) to establish strong relationships between researchers and other actors in technological innovation 7) to involve development partners in research activities in a dynamic way 8) to allow policy makers to appreciate research on a concrete basis and to shed light on their strategic choices 9) to create a synergy and reinforce the relationship between research structures 10) to help young people to develop research and technological vocations 11) to evaluate the state of the research and 12) to give the public detailed and reliable information on research and technology and progress towards the twelve objectives.

development with the aims of: 1) updating the potential of research to contribute to the country's development; 2) making the main research centre (CNRST) a tool and means to promote and coordinate research to realise the government's development objectives (CNRST, 1995).

Shortly after the creation of the forum (FRSIT) in 1995, which initially focused on the links between the government and researchers, there appeared the need to complement it by bringing industry into the network. This was accomplished by the creation of the Salon of Inventors and Innovators (SNII) by the Ministry of Industry, Trade and Craft. However, although one can detect some attention to the existence of systems through this initiative (all three key components, government, research and industry, are present), further analysis shows that the theoretical background is similar to the traditional linear way of approaching the innovation process (redolent of the 'science push' and 'demand pull' models - Manley, 2003). As the Ministry of Higher Education has highlighted, "The different actors (inventors, innovators, researchers, users of research results and decision makers) work independently. Indeed, within an institution or actors' group, the linkages are not perceived or even non-existent" (FRSIT/CRDI, 2008:1). None of the original objectives of the FRSIT show that the underlying model of the role of science and technology in the development of the institution goes beyond these traditional models to innovation processes.

It is only from the early 2000s that the concept of NIS appears clearly in policy circles and with it a less linear approach to research and innovation. This new development strategy in policy discourse became explicit and was detailed through the five years of the FRSIT/CRDI collaborative research project on "the analysis of the innovation systems and strengthening of linkages between actors for socio-economic development in Burkina Faso" (FRSIT/CRDI, 2008:1, 2009:1). The project was introduced into Burkina Faso as a specific project of innovation diffusion in 2006 and by IDRC/CRDI Canada, who themselves were inspired by the wider literature on 'national innovation systems'. The aim[2] of the project was to understand[3] innovation development and facilitate access to finance and loans. The project included a training workshop on "the analysis of innovation systems and the strengthening of linkages between actors for the socio-economic development of Burkina Faso"[4] (FRSIT/CRDI, 2008:3). Since 2010, the FRSIT which led the NIS project[5] has been integrated into the policy department of the newly created Ministry of Scientific Research and Innovation (MRSI), with the effect of providing a policy narrative for the country's developing science, technology and innovation policy[6].

1.1.3 Cotton in Burkina Faso: A Suitable Target for Research and Innovation

As in many other developing countries, agriculture is the main economic sector in Burkina Faso. It employs almost 90% of the total population. It is also the sector through which research began in the country. Finally, it is one of the most dynamic

[2]1) identify and understand the needs of the users of the research results 2) organise users and producers of innovation with respect to their competence 3) access more easily loans from banks 4) establish partnerships and negotiate contracts and 5) support policy making decisions.

[3] The project had two phases. First the researchers at the FRSIT were expected to familiarize themselves with the NIS framework, as a theory, by studying cases of sectoral innovation. The second phase was to support the translation of the NIS framework, as a policy frame-work, for socio-economic knowledge-based development.

[4] In French : analyse des systèmes d'innovations et renforcement des liens entre les acteurs au service du développement socio-économique au Burkina Faso

[5] This represents the outcome of the second phase of the project.

[6] Plan d'Action Prioritaires de la Politique Nationale de Recherche Scientifique et Technologique (PAP-PNRST); Politique Nationale de la Recherche Scientifique et Technologique (PNRST) Plan d'Action Operationnel de la Strategie National de Valorisation des Technologies, des Inventions et des Innovations (PAO-SNVTII) ; Strategie National de Valorisation des Technologies, des Inventions et des Innovations (SNVTII). All these plans and strategies were adopted in 2012 and incorporate FRSIT/CRDI activities and plans.

sectors and is in some ways in advance of others with the implementation of state development policies.

Within the agricultural sector, one specific crop has attracted my attention, cotton. Cotton production is an interesting case to investigate as it was the first cash crop in Burkina Faso, and now makes up about 60% of the country's economy. Moreover, compared with other crops, cotton production involves a wide range of actors such as firms and knowledge providers, as well as large and small producers. The sector has also faced long-standing demands for innovations to improve productivity, as well as health and economic growth. The scale and importance of this sector, combined with the potential for improvement based on scientific research, suggests that the cotton industry is highly appropriate as a target for the application of the NIS as a policy narrative. Moreover, its size and significance means that it merits attention and analysis as a site for this investigation.

1.1.4 The Sectoral Innovation System of Cotton

Until the early 2000s, Burkina Faso had a strong sectoral cotton innovation system.

However, this established innovation system faced a crisis from the early 1990s (Schwartz, 1996; 1997) when cotton crop productivity started to show signs of rapid decline. In addition to soil degradation and less rain resulting from climate change, the most significant problem was insect infestation which appeared in the 1980s and became worse in the 1990s (CNRST, 1995; World Bank, 2004; AFD, 2008). There was an increase in the volume of pesticides used due to the growing numbers of insects. These infestations can sometime be disastrous and lead to a high damage rates of up to 90%[7] (CNRST, 1995; CNRST, 2007). All these issues deeply affected conventional cotton expertise which was losing its very promising position (Schwartz, 1997; Roberts, 1997).

The significant insect damage combined with the rainfall instability, soil degradation and chemical dependence called specifically for an alternative to using increasing amounts of chemicals to redress the declining trend of cotton cultivation and productivity. A clear alternative in the form of biotechnology cotton presented itself. Monsanto's Bt cotton[8] was identified as an alternative way to fight insects and a means of reversing the decline in cotton productivity, and seemed to be a relevant application in this particular context. With Monsanto's Bt cotton, the aim was to improve the quantity and also the quality of production, with less damage to the cotton during its growth. For this reason, biotechnology cotton, i.e. genetically modified cotton, was seen as one of the solutions for increasing cotton production (CES, 2011). INERA, the agricultural research centre, attests that "to play its role, there is a necessity for research to accept robust technology such as modern biotechnology" (INERA, 2011: 3).

The shift to a Bt cotton solution originated in a meeting with Monsanto in Cameroon in 1999. This was followed by the first official meeting with Monsanto in 2000 and again in 2003 in Burkina Faso. The different interested parties (researchers, industries, farmers and the government representatives) acknowledged the extent of the insect

[7] SOFITEX, presentation during workshop on biotechnology held in 29th March to 19th of April, Ouagadougou, Burkina Faso, in which I took part [29/03/2011 to 19/04/2011]

[8] Bt = Bacillus thuringiensis, a cotton genetically modified by the insertion of one or more genes from a common soil bacterium called Bacillus thuringiensis. These genes encode the production of insecticidal proteins, and thus, genetically transformed plants produce one or more toxins as they grow.

damage to conventional cotton and considered the solution brought forward by Bt cotton. “All the actors present at the first and second meeting had shown an interest towards biotechnology cotton to fight against insect damage” (042011#01). Additionally, during a workshop organized by the President’s advisors held between 29th March to 19th April 2011, the National Union farmers, industries and government representatives all agreed that biotechnology cotton was one of the alternatives to fight against insects’ resistance.

Of all the sectors subject to the use of the NIS as a policy narrative by the government, I was drawn to look at its implementation and effects in a system in the agricultural sector. More specifically, given the position of cotton as a main cash crop with a quite well organised system of actors, I decided to look at the innovation system in the cotton sector with a specific focus on the Bt innovation system.

The focus on the Bt cotton innovation system brings into view the concept of a Sectoral Innovation System (SIS). An SIS is a specific form of innovation system. The innovation systems have been categorized into national, regional, local, technological and sectoral innovation systems. An SIS approach aims to analyse the innovation process, the factors affecting innovation, the relationship between innovation and industrial dynamics, the changing boundaries and transformation of a specific sector, and the determinants of the international performance of firms and countries in relation to a specific sectoral level, in this case, the cotton sector. An innovation system in a sector is considered to be affected by three groups of variables: knowledge and technologies; actors and networks; and institutions (Malerba, 2002; 2004; 2005). For Malerba, the concept of a sectoral system of innovation is a multidimensional, integrated and dynamic view of sectors. He proposes that “a sectoral system is a set of products and the set of agents carrying out market and non-market interactions for the creation, production and sale of those products" (2002:247).

The choice of Bt cotton innovation serves to highlight the underlying policy narrative which is used for its implementation in the cotton sector. My intention here is to show the extent to which the adoption of Bt cotton technology has been innovative or not, in terms of the existing innovation system (organisational system), bringing into existence a new way of interaction between the involved set of actors.

This thesis therefore explores the SIS for cotton from the perspective of the operation of a pre-existing National Innovation System, and the impact of the introduction of the Bt cotton innovation. It examines how these two innovation projects, the NIS and Bt cotton, played out, given the socio-technical and organisational systems in place in Burkina Faso at the time.

The study is carried out within the interdisciplinary field of Science and Technology Studies (STS), which sees the use of technology as a socially-embedded activity entailing specific forms of knowledge. In particular, the various analytical concepts within the STS field have relevance in relation to the attention paid to the nature and role of innovation. Of the main STS conceptual frameworks available, this thesis adopts the Socio-Technical Systems (ST-Systems) conceptual framework because it is capable of considering the whole system of innovation from production through to diffusion and use. This analytical concept will enable me to identify the social actors (niche, regime and landscape level actors) across the entire ST-System involved in the adoption and implementation of the NIS policy tool for innovation diffusion, as well as the impact of the subsequent Bt cotton innovation. The relations between these actors form the social infrastructure necessary to successfully develop, diffuse and use innovation to meet developmental goals. These interrelations both at policy and operational levels thus form the basis of my analysis.

This thesis concentrates on how these two innovation projects, NIS and the Bt Cotton, proved to be incompatible and incapable of enhancing Burkina Faso’s innovation policy. Rather than using and building on each other’s strengths, it will be shown that the two projects were prevented from inspiring each other, largely as a result of the way that the socio-technical and organisational systems in place in Burkina Faso were set up and operated. The thesis will evaluate the implementation of both the current National Innovation System framework as an innovation diffusion approach for socio-economic development in Burkina Faso and the adoption and implementation of Bt cotton were being shaped by local actors in their competition for control of financial resources and power positions, resulting in significant problems with both projects.

1.2. Research Objectives

The key aim was to investigate the two projects, the NIS inspired policy framework and the Bt cotton innovation system, in facilitating development in Burkina Faso at both strategic policy and operational levels by investigating the following specific aims:

- To investigate the introduction, development and implementation of a National Innovation Systems (NIS) for innovation diffusion in Burkina Faso

- To demonstrate the application of the NIS with particular reference to the cotton industry, prior to 2003

- To investigate the introduction of Bt cotton, as a case study of an attempt to address the shortcomings of the existing innovation system, and innovate it.

- To evaluate the outcome of the implementation and interaction of both projects in Burkina Faso

1.3. Research Questions

❖ To what extent can it, or can it not, be claimed that the National Innovation Systems (NIS) framework adopted in 2000s to foster systemic innovation has facilitated socio-economic development in Burkina Faso, with particular reference to the cotton sector and the introduction of Bt cotton?

  - How has the NIS as an innovation diffusion approach been translated in Burkina Faso, with specific reference to the Bt cotton innovation system. Which institutions/actors played a key role in its implementation?

  - What expectations were there that the application of the NIS approach to the cotton sector in Burkina Faso would facilitate socio-economic development and to what extent were these met by the introduction of Bt cotton?

  - In what ways did the Bt cotton innovation diffusion in Burkina Faso challenge the existing NIS?

- What are the strengths and limitations of using the NIS framework as a policy tool for facilitating relations between the institutions and actors in an innovation system such as the Bt cotton system in Burkina Faso?

1.4. Why this Research is Important

1.4.1. The Limited Literature on the Translation of NIS Framework in Policy Circles in Developing Countries

Within the African context, literature investigating the use of the as a policy tool has only recently begun to emerge. For example, Ecuru et al. (2011) have discussed recent policy design in Uganda by reviewing the country's strategy to integrate science, technology and innovation in its development planning. A subsequent publication (Ecuru et al., 2012) shows that their interest in the issue is focused on NIS as an "analytical tool" for an African country such as Uganda (Ecuru et al., 2012). In other words, NIS is used as a research framework to investigate development planning, rather than NIS as an object of research. It is this similar focus which is found in the collected *Putting Africa first: the making of African innovation systems* by Mammo Muchie and collaborators (Muchie et al. 2003). This aspect (NIS as an "analytical tool" for researchers) lies outside the focus of the present thesis.

To date I found only 3 major papers which investigate the NIS as a policy tool, in a way that is similar to the focus of this thesis. Indeed, Cambrosio, Limoges and Pronovost (1990), in their now classical paper, *'Representing Biotechnology: An Ethnography of Quebec Science Policy'*, have shown that policy practices are culturally and institutionally embedded, thus highlighting the importance of models in the understanding of how policy practices operate. Building on this scanty literature, Albert and Laberge (2007) have investigated *'The Legitimation and Dissemination Processes of the Innovation System approach: The Case of the Canadian and Québec Science Technology Policy*'. They have shown through their case study that the NIS framework served as a guideline for science policy making in the country. According to the authors, the adoption of the innovation system by the Quebec government is related to the 'symbolic power' in the prestige of the OECD's countries. In addition, the recognition of science as a means for economic growth has contributed to the formation of guidelines for science policy making in the country. Moreover, Sharif (2009) carried out research on *'Rhetoric of Innovation Policy Making in Hong Kong Using the Innovation Systems Conceptual Approach'*. Through his case study**,** he gives a better understanding of how the option of the 'new strategy' in the country's innovation, technology and policy making is essential for the understanding of the NIS as a policy tool. As he said:

> the IS conceptual approach is being used as a rhetorical resource by the Hong Kong Government in its innovation and technology policy, making it an effort to persuade its perceived audience of the efficacy of its new strategy for its policies—policies that are in fact unrelated to the basic precepts of the IS conceptual approach. (Sharif, 2009: 1).

In particular, for Sharif (2009: 21): "perhaps more fundamentally, the IS conceptual approach may itself be deficient, and its shallowness, ambiguity, and interpretive flexibility are precisely what has permitted its widespread dissemination". In a quite different area, Ngoasong (2010) successfully examined the role of models in shaping policy practices through the study of the *'Role of global health partnerships in shaping policy practices on access to medication in Cameroon'*.

As can be seen, Cambrosio, Limoges and Pronovost (1990) were not interested in biotechnology, but instead focused on the way the NIS framework has been used to develop science policy in order to implement it. Also, Albert and Laberge (2007) were not interested in science and technology policy, but the NIS model embedded in such policy. In his turn, Sharif (2009) was not focusing on innovation policy but the NIS model which shaped the innovation policy. Last but not least, (Ngoasong, 2010) was not interested in malaria or HIV per se, but in the organisational model of global health partnership used to organise the delivery of medical services to combat HIV and malaria. Their focus here on the given sector was just a practical strategy because the model is related to the general development policy of each country.

The present thesis sets out to address this knowledge gap, particularly in the African context. In the same way as the above literature, this research is not about biotechnology, but the policy narrative used at the operational level to implement biotechnology cotton. It is not about the agriculture sector, but about the model which shapes the development strategy of Burkina Faso as a whole. In other words, all sectors are informed by the same model, but for pragmatic reasons I selected a case of innovation in one sector. My choice of biotechnology cotton is therefore part of the methodological choice of the thesis. The main aim is to study empirically the implementation of the NIS policy tool. What matters here is to be able to study the implementation of the framework in a specific sector, which could equally well have been health or education. The choice of the agricultural sector here and biotechnology cotton in particular, is in recognition of the sector's higher level of development than others, which do not have the same level of use of knowledge as a means of development, with each sector under a specific ministry, with differing dynamics. Although national policy defines the framework for all sectors, some ministries have been slow to develop their own sectoral policy, based on the state's general framework. In this regard, my choice was influenced by the active and dynamic nature of the Ministry of Agriculture and agricultural research department (INERA). Since independence, agriculture has been one of the first areas in which scientific resources have been deployed in order to increase agricultural productivity, which, it was hoped, would improve the well-being of the whole population.

Adopting an STS approach to study the transfer and implementation of the NIS framework as a policy tool in developing countries such as Burkina Faso is as important as the flourishing theoretical debate on its use as an analytical framework by researchers. Because, if research on the latter is now common, the study of the NIS as a "development tool" in policy circles in Africa and in developing countries more generally remains scanty. The evolution of development policy strategies in Africa and particularly in Burkina Faso supports the policy relevance of such a study.

1.4.2. Relevance to Policy in Burkina Faso

Towards the end of the 1990s, innovation was increasingly considered as an alternative means of development within the framework of knowledge-centred development (Cimoli et al. 2009; Rist 1997). This makes the unpacking of the social assumptions behind the models that shape development planning highly important. The knowledge-centred development model is the third in the history of development thinking and practice. Prior to moving to this third model, Burkina Faso made two unsuccessful attempts to implement innovation.

The first attempt by the government of Burkina Faso conformed to the institutionalist model, which dominated development policy between the 1950s and 1970s (Rapley, 1997). When the concept of 'development' entered international relations at the end of the 1940s, it was on the basis that the application of a western conception of market-based economics would produce the desired result – increased economic activity. It posited that high labour mobility from traditional to non-traditional activities is the driver of growth (Cimoli et al. 2009; Rist 1997). As a director of policy, the role of the state is to establish collaboration between the public and private sectors to overcome information and coordination failures; to develop institutions to support investment in self-discovery and the diffusion of new activities in markets (World Bank, 1988; 1999; OECD, 1999; Cimoli et al. 2009).

Burkina Faso's development policies[9] from 1960 to 1983 were shaped by this institutionalist model and all aimed to improve people's life conditions. They believed, as clearly stated in the 1963-1967 development plan, that to this end, the policies should "make sure people in Upper Volta move to a higher technical and cultural stage" (in Gerardin, 1964:111), and "put in place development structures, schools etc., proper administrative and political measures to modify behaviour, to

[9] 'Plan Triennal 1960-61-62' [Three Year Plan 1960-61-62]; 'Premier Plan Quinquenal de Development 1963-1967' [1st Five Year Development Plan 1963-1967]; 'Plan Cadre 1968-1970' [Framework Plan 1960-1970]; 'Plan Interimaire 1971' [Interim Plan, 1971]; 'Deuxieme Plan Quinquenal du Development Economic et Social 1972-1976' [2nd Five Year Socio-economic Development Plan 1972-1976]; 'Troixieme Plan Quinquenal du Development Economic et Social, Avant Projet 1977-1981' [3rd Five year Socio-economic Development Plan 1977-1981]

make a certain number of public administrations work together or to facilitate an expansion...” (in Gerardin, 1964: 111). In line with the modernisation theory which is embedded in the institutionalist model, they expected that technical, cultural and administrative development and modernisation would be achieved through the importation of ready-made technology and trained staff from abroad, notably from developed countries (Gaillard, 1999). This view is supported by the data which shows that, during this period, higher education and research had not been mentioned in any of the policies. The technological transfer did not contradict the assumptions of the linear model of innovation which dominated this period (Manley, 2003). From the institutionalist perspective, indicators of development are the degree of diversification of the economy, and the degree of urban activities in the economic structure.

However, by the end of the 1970s, the modernisation paradigm did not result in the general prosperity promised. Instead, developing countries continued to become increasingly poor, and within them only a small social category, representing the international capitalist branches and political elites, benefited from any wealth creation. The changes from traditional development strategies to more modern tactics did not happen. By the end of the 1970s, the policy measures taken by the Burkina Faso government based on this model had not resulted in the improvement of the living conditions of the majority of the population, as reflected in the key development indicators (World Bank, 1987; 1981).

- ***Economic development***

  In the 1970s, the proportion of the labour force employed in the agricultural sector was still high: 87% in 1975 compared to 92% in 1960. The structure of exports shows 0% in 1960 and 6% in 1975 for manufactured merchandise; 100% in 1960 and 94% in 1975 for primary commodities meaning that there was little improvement in the development of secondary sectors. During the same periods, average exports were respectively 48% and 24% in industrialised countries with a strong extraverted economy. Exports to industrialised countries rose from 4% in 1960 to 72% in 1976. Indeed, at the end of the 1970s, the average annual growth of the GNP per capita remained very low. Between 1960 and 1976, it only increased by 0.8% well below the average of low income countries' (0.9%) and industrialised countries' (3.4%). This means that on average every individual had an income of $110 per year in Burkina Faso whereas it was $150 in low income countries and $6,200 in industrialised countries.

❖ ***Health conditions***

There was little improvement in the health of the population. The crude mortality rate was 25‰ in 1975 whereas it was 31‰ in 1960. In industrialised countries, it was respectively 10‰ and 10‰. The average life expectancy in Burkina Faso was 38 years in 1975 whereas it was 72 in industrialised countries (World Bank, 1978; 1981).

❖ ***Education***

Many people remained uneducated; only 14% received primary education in 1975 while in industrialised countries it was 100%. In secondary school, there were only 2% of the population whereas it was 83% in industrialised countries (World Bank, 1978; 1981).

Burkina Faso sought to improve this situation by developing new policies[10] under the competing model of development based on dependency theory between 1980 and the 1990. Dependency theory interprets ‘development’ and ‘underdevelopment’ as socially embedded and interrelated processes. It supports the idea that the economies of the countries of the South are better understood within the international economic system. For example, according to this theory, colonisation destroyed the social and economic features of countries under domination and blocked their natural evolution. Models based on dependency theory consider that market competition led to the formation of monopolies and ‘free’ trade arrangements enabled monopolies to continue their expansion through the internationalisation of domestic markets. Proponents of dependency theory-based models ‘concluded from their own observation that the international system, far from guaranteeing the South’s prosperity, brought the effects of domination to bear upon it and locked it in dependence’ (Rist 1997: 109). In terms of policy these models advised that countries of the South should opt out of the system by developing their industry, including appealing for foreign capital, form regional groups and encourage state intervention to control inequalities through land reforms and the redistribution of investment. In most cases this would require radical social change (e.g. revolution) (World Bank, 1999). Several plans were designed

[10] ‘Quatrieme Plan Quinquenal de Development 1982-1986’ [4th Five Year Development Plan 1982-1986]; ‘Plan de Base ou Programme Populaire de Development 1984-1985’ [Basic Plan or Popular Plan for Development 1984-1985]; Rapport Sectoriel du Plan Quiquenal de Development Populaire 1986-1990’ [Sectoral Report on the 4th Five-year Development Plan 1986-1990]

within this framework. The revolutionary regime in place in Burkina Faso set out to achieve independence and economic autonomy.

The policy option suggested that all development plans for the country would involve the engagement of each individual. The efficiency of mass labour relies on a clear framework of a planned economy. It applied to all national and regional sectors. The aim was to deal with the urgent and pressing needs of the population which are: food, water, housing, education, health, culture and sport. In relative terms, this strategy is considered by many analysts to have resulted in significant improvement in the living conditions of the majority of the population.

- ***Economic development***

For instance, in 1988 the proportion of the labour force in agriculture has reduced to 56% from 87 % in 1975. The structure of exports shows 98% in 1988 for manufactured merchandise, and just 1% in 1988 for primary commodities, meaning that there was some improvement in the development of secondary sectors to transform local primary goods.

- ***Health conditions***

The average life expectancy in Burkina Faso was 47 years in 1988 whereas it was 38, 13 years before.

- ***Education***

Primary education increased from 14% in 1975 to 32% in 1988, almost doubled in 13 years. Enrolment rates in secondary school tripled (2% in 1975 to 6% in 1988).

However, this revolutionary experience was stopped at the end of the 1980s through political change, with the result of undermining the developmental achievements of the period. In a newly liberalising political regime the economy slowed down as it suffered from the international economic crisis. It is in this context that a new development paradigm based on economic orthodoxy made a comeback, and dominated development discourse.

The institutionalist model was later displaced by the market model. The market model dominated development discourse between the 1980s and 2000s. According to this model, markets have the potential to generate their own internal coordination (World Bank, 1999). For this reason, deliberate coordination of individual efforts is irrelevant and counterproductive, because competition provides opportunities for workers and producers and leads to high quality service (Ibid). The Structural Adjustment Programme (SAP) policy recommendations included the promotion of private investment in physical and human capital and new knowledge. Competition – market entry and exit, free-trade, export and foreign development investment would enable knowledge spill over (Rist, 1997).

The argument was that developing countries do not need to invest in advanced science and high technology, because free trade would enable their transfer from developed countries. Politically, the displacement of the problem of development from international negotiation, as required by the New International Order, to a humanitarian framework allows intervention by Western countries using political pressure to change political regimes that do not respect 'human rights'. Essentially this conceptual shift owes much to the influence of a competing development paradigm commonly called 'dependency theory' and civil society action. This has resulted in the redefinition of the development concept as 'human development' which goes beyond the initial neo-liberal understanding of development as growth.

In the beginning of the 1990s, the concept of development had become almost uncontested as it managed through the past decades of debate to integrate a wider view, so that in addition to being universal 'development' was becoming more and more trans-cultural. This is observable in the scope of indicators of measurement, which now included productivity growth rate, human rights (early 1980s), environmental protection (late 1980s), development as self-reliance, and human development (in 1990s). In the same way, Burkina Faso development policies[11] at that time were shaped by the market. In 1991, the authorities decided in line with the financial crisis to make structural reforms with the help of international financial bankers and,

[11] 'Rapport Sectoriel du Plan Quiquenal de Development Populaire 1986-1990' [Sectoral Report on the 4th Five Year Development Plan 1986-1990] ; 'Programme d'Ajustment Structural, 1990-2000' [Structural Adjustment Programme, 1990-2000]

from the beginning of the 1990s, the structural adjustment programme has dominated Burkina Faso's development strategies. Many public sectors have been privatised and, until the end of the 1990s, development strategy was led by the Structural Adjustment Programme (SCADD, 2011). However, by the end of the 1990s, the achievements of the 1980s were lost.

- ***Economic development***

The period 1990 to 2000 has seen a decrease in Burkina's socio-economic development. Indeed, the market economy theory which informed the model adopted by the country following the political shift at the end of the 1980s did not result in an improvement in living standards for the population. Between 1980 and 1990, the GDP was 3.6%, and between 1990 and 1998 it was 3.5%.

- ***Health condition***

Life expectancy dropped from 47 years in 1988 to 45 years in 1997. The mortality rate per thousand children under 5 was 169 in 1997; Infant mortality rate per thousand live births was 99 per thousand in 1997; and maternal mortality 93 per thousand live births, higher than the 1980s.

- ***Education***

Adult illiteracy in 1997 was about 80%. The net enrolment ratio in primary school was 31% in 1996 compare to32% in 1988.

In this context, at the end of the 1990s, Burkina Faso designed a policy[12] to complement the Structural Adjustment Program (SAP) known as 'Poverty Reduction Strategic Papers' to mitigate the drawbacks of the SAP. The key objective of such an enhanced framework was to "assist countries in developing and implementing more effective strategies to fight poverty" (World Bank, 1999:6). Nevertheless, little improvement was apparent from the new strategy 10 years later. For instance, nearly half of the population still live below the poverty line (43.9% of population lived below the poverty line 108.454 in 2009/2010) despite the steady growth during the previous 10 years; average 5.2% (2000-2009) with 8.7% in 2005. The market model appeared to be undergoing a serious crisis as Joseph Stiglitz and his collaborators observed in their book, *The Crisis of the Growth Paradigm*: "We began this book with the inevitable reference to the 'Washington Consensus' and the damage done by the almost religious implementation of such an extremist version of economic orthodoxy. The times of the 'Consensus' are over, buried by the weight of its economic failures, in addition to its massive social disruptions" (Cimoli, et al.2009: 557). An opportunity had opened for a new model of development, this time based on innovation.

Towards the end of the 1990s, innovation came to be increasingly considered as an alternative means for development within the framework of knowledge-centred development. Many meetings were held in the African continent from 1998 onwards to debate the extent to which scientific and technological advances could aid development in underdeveloped countries. The following

[12] 'Cadre Strategic de Lutte Contre la Pauvrete, 2000-2010' [Poverty Reduction Strategy Papers, 2000-2010]

table gives a full list of chronological events which took place in Africa in the process of the use of knowledge (innovation) as a key for development.

Table 1: Key events in the construction of Africa's innovation systems

	Organisation	**Event/meeting**	**Location**
1998	World Bank	Report on *Knowledge for Development*	Africa (not specified)
1999	UNESCO	Conference on *The Role of Science in the Twenty First Century, the New Commitment*	Africa (Not specified)
	Knowledge Management Africa (KMA)	Conference on *Knowledge to Address Africa's Development Challenges*	South Africa
2001	NEPAD	Creation of NEPAD to create new conditions for development in Africa.	
2003	The African Ministerial Council on Science and Technology	1st meeting aiming to put in place the National Science and Technology Innovation (STI) policies	Johannesburg (South Africa)
2005	The African Ministerial Council on Science and Technology	Put in place the National Science and Technology Innovation (STI) policies	Dakar (Senegal)

	(AMCOST)		
2007	OECD	Made available some guidelines for African countries This sentiment was expressed in the *Addis Ababa Declaration on Science, Technoloy and Scientific Research for Development* at the African Union Summit in January 2007.	Addis Ababa (Ethiopia)
2009	OECD and UNESCO	Organised a joint workshop which was held on *Innovation for Development: Converting Knowledge to Value*.	Not specified
	OECD	A meeting on *Innovation out of Poverty*	Not specified
2010	OECD	Publication on *Innovation and the Development Agenda.*	

Source: Processed by author

As shown in Table 1 above, research and development as mechanisms to improve policy and promote technological innovation became part of the development agendas in Africa, as reflected in the titles of the World Bank report (1998) on *Knowledge for Development;* and the *1999* UNESCO conference on *the Role of Science in the Twenty First Century, the New*

Commitment. The first meeting of the African Ministerial Council on Science and Technology (AMCOST) held in November 2005 emphasised that, as a matter of priority, all countries should have comprehensive national Science and Technology Innovation (STI) policies with emphasis on the development of effective National Systems of Innovation. In Addis Ababa in 2007, the OECD made available some guidelines for African countries. The sentiment was expressed as follows:

We, the Heads of States and Government of the African Union, recalling our millennium commitments to achieve sustainable development for our Continent, ...realizing that the achievement of these goals depends on our countries' abilities to harness science and technology for development and also an increased and sustained investment in science, technology and innovation, ...commit ourselves to promote and support research and innovation activities and the requisite human and institutional capacities (UNESCO, 2007: 5-6)

Later, in January 2009, the OECD and the UNESCO organised a joint workshop which was held on *Innovation for Development: Converting Knowledge to Value*. In April 2009, a meeting of experts on *Innovation out of Poverty*, was held, by the OECD Development Co-Operation Directorate. And in 2010, the OECD laid down a framework "for putting innovation on the development agenda" through its publication *Innovation and the Development Agenda.*

The NIS narrative, in particular, provides the framework for intervention in this regard. A number of countries, national and international bodies have used the NIS policy tool to implement their innovation policies. As for the countries which have used such tools to develop their national policy strategy, they include for instance, the USA, Japan, Russia, Brazil, China, South Africa, India (Lundvall, 2007). Similarly, Canada and Quebec have both implemented the NIS tool for their science and technology policy (Albert and Laberge, (2007). Hong Kong has applied the NIS conceptual approach in its innovation policy formulation (Sharif, 2009). In addition, international organisations such as OECD, the United Nations Conference on Trade and Development (UNCTAD), the World Bank and the EU commission have adopted the concept to inform their innovation policy strategies (Lundvall, 2007). Even in the least developed countries, the model is becoming increasingly popular in policy circles. For example, more recently, the government of Uganda attempted to use the model (NIS as a development tool) to integrate science technology and innovation in its development planning process (Ecuru et al., 2011; 2012).

The literature in development studies has already shown that many developing countries embrace global models of development for financial purposes independently of the effectiveness of such models in bringing about socio-economic development. The high interpretive flexibility of the NIS (different meanings associated with the framework) makes it even more interesting to investigate.

1.5 Research Methodology

I used Geels' ST-Systems analytical framework to study the NIS as a policy narrative to transform the existing NIS (physical reality) of the country. This analytical framework will help understand the case of the NIS innovation approach adoption and outcome. In addition, the nature of the problem addressed in this thesis made it necessary to adopt a qualitative approach, drawing on ethnographic techniques to collect and analyse the data.

Ethnography here will be considered in its 'modern' sense, in a way that will enable me to investigate not only the historical dimension pertinent to this research, but also to consider it as a network. For example, in the case of the NIS policy tool implementation, there are researchers, policy makers, cotton industries, cotton farmers, other users of research results, inventors/innovators, and multi-national actors interacting in a network. This wide range of actors cannot be simultaneously in one specific space for a long enough period, therefore the nodes (laboratories, offices, firms, hospitals, business centres, private residences) (Latour and Woolgar, 1996) of this network of actors are going to be investigated in this research because it appears unnecessary and unreasonable for me as a researcher to travel to all these places and follow actors' everyday routines as ethnographers may have done in the past. Thus, ethnography is going to be considered in this thesis as it is used in science studies as well as in its neo-modern sense (Comaroff 1992: xi). This has implications for the data collection strategy through interviews and meetings. In addition, in my application of the ST-Systems analytical concept it was necessary to complement it with concepts from other approaches, particularly Techno Economic Network (TEN), Actor Network Theory (ANT) and Social Construction of Technology (SCOT) for the additional insights they offer in relation to networks, and in relation to the weaknesses of the ST-Systems analytical framework

Documentary and interview data will be transcribed and subjected to thematic analysis. It is this scheme of analysis which will enable me to understand the shaping of the ST-Systems of the current NIS policy tool and the Bt cotton innovation system in the course of their transfer and implementation.

1.6 Structure of the Thesis

In addition to the introductory and concluding chapters, this thesis is organised into three parts. Each part is composed of two Chapters.

Chapter 2 will demonstrate that the processes involved in the NIS policy tool for innovation diffusion adoption with multiple interlocking actors call for a multi-level perspective (ST-Systems) of the kind that Geels (2004), Geels and Kemp (2007) offer. As a result of that, taken as a social technology, the analysis of the NIS policy tool adoption and implementation is going to be treated in the light of the S-T Systems analytical framework.

Chapter 3 will give a detailed description of the research design and methods to be used for collecting and analysing data. It will make clear that an ethnographic approach was the most appropriate approach among the available qualitative research approaches for the study of the NIS policy tool for innovation diffusion adoption in Burkina Faso. This approach is considered suitable because the methods it provides are the most appropriate given the kinds of processes which are the focus of the thesis.

These methods will involve documentary analysis, direct observation, and semi-structured interviews, consistent with the practices of STS research.

Chapter 4 will investigate the crisis in the socio-technical regimes as a result of the pressure from the socio-technical landscape in order to address its implication for the adoption of the NIS policy tool as a new approach to innovation. Three different approaches to innovation have been investigated for some insufficiencies on the level of participation of the involved actors. The lack of participation in the integrated approach around cash crop will make explicit the linear process in innovation diffusion as shown with mechanisation in the agriculture sector. In addition, the Training and Visits approach, which was more or less participative, has centred the job of the technical support agent as an intermediary between end users and researchers. The level of participation is limited to moving with information instead of open dialogue between innovation actors. The latest participative approach named Farming Systems (systems approach) will give credit to participation as essential for successful innovation diffusion. This will lead me to examine the changes in the corresponding innovation approaches and the science policies of the period, as well as the organization that was put in place for their management.

Chapter 5 is going to investigate the process through which the NIS policy tool was adopted and its diffusion at policy level. In so doing, the chapter first of all will describe the Forum of Scientific Research and Technological Innovation (FRSIT), as a niche within which the NIS policy tool for innovation diffusion was transferred, by describing its context of creation, its missions and its organisational set up for innovation management. Secondly the chapter will look at the process of stabilisation of the NIS policy tool at niche level, by highlighting the learning processes, the experimentation and the network building involved in its stabilisation. Such learning processes consisted in undertaking training sessions, meetings, symposiums, workshops and conferences in order to evaluate it and build up the network of relevant actors who are interested in adopting the technology. It will at the end make an appreciation of the institutionalisation of such a policy tool to diffuse innovation, through an analysis of its adoption and diffusion process as manifested in the policy design.

Chapter 6 will identify the three main ST-Systems in relation to cotton growth in Burkina Faso and explore the way in which the shift from one system to another took place. These ST-Systems will be: the pre-colonial; the colonial; and the postcolonial (which officially ended in 2003). The analysis reveals that the co-evolution of cotton production, the political economy of Burkina Faso, forms of social organisation, and institutions with human actors, gave specificity to each ST-System at a given time. In other words, the type of cotton, the growing techniques, the organisation, the involved actors and the purpose of cotton growth will all be considered as specific to each historical epoch. The findings will enable us to make evaluative statements on the nature and extent of the impact of colonisation on the development of a modern economy in Burkina Faso. This chapter will prepare the way for Chapter 7, which considers Bt cotton adoption and evaluates the framework which informed actors' interactions.

Chapter 7 will then give the context of the diffusion of construction of the Bt cotton innovation system, it will analyse the translation process and implementation of Bt cotton in order to highlight the underlying innovation approach which backed up such processes and thus shaped the outcome of Bt cotton technology. What is important is to investigate the extent to which the NIS approach did or did not manage to displace the existing innovation approach in order to establish itself as the new approach which would increase productivity through Bt cotton innovation implementation. By looking at the linkages of actors in the Bt cotton innovation implementation, it will be possible to evaluate if it is the NIS policy tool or another approach behind the behaviour of the involved actors.

Finally, conclusions which bring together the findings of the whole thesis, an evaluation of the two projects, the NIS policy tool and the Bt cotton innovation system. The theoretical contributions of the present thesis and some proposed possible future research will be presented in **Chapter 8** of this thesis.

Part I

Research Methodology

Chapter 2: Understanding the Use of the Framework in Facilitating Socio-Economic Development: A Review of the Key Literature

2.1. Introduction

The introduction and use of the NIS as a policy tool in Burkina Faso represented a significant shift of policy focus, given the history of previous policy models in relation to economic development. The fundamental change reflected a move to a knowledge-centred model. For this new policy narrative to have a reasonable chance of being successful, the NIS, as a policy tool, needed to be translated – understood, interpreted, and tailored to fit Burkina Faso's socio-political, economic and developmental realities – and then applied and implemented effectively.

Accordingly, the review of relevant literatures in this chapter has the objective of choosing an appropriate analytical approach, design and methods to examine the result of the process of adoption of the NIS.

This present chapter therefore is going to first of all briefly define the key concepts (National Innovation Systems, Development, Knowledge Centred Development policy and Social Technology) which are going to be used throughout the thesis. A brief overview of the Innovation System of Burkina Faso will also be given here. In addition, and more importantly, this chapter will show that STS theories such as Techno Economic Networks (TENs), Actor Network Theory (ANT), and Social Construction of Technology (SCOT) remain individually neither sufficient nor adequate for a study of the particular phenomenon of the National Innovation Systems

(NIS) as a policy tool adoption in Burkina Faso for its socio-economic development. However, one STS-informed approach, the Socio Technical Systems (S-T Systems) or known as the Multi-Level Perspective (MLP) approach, does stand out for its ability to focus on innovation's social and technical environment processes and its impact within the context of socio-technical systems, and so provides a coherent and incisive basis for this case study of the NIS policy tool adoption in Burkina Faso, including an analysis of its outcomes for actors involved in the cotton sector.

2.2. Definition of Key Concepts

2.2.1. National Innovation Systems

2.2.1.1 National Innovation Systems as an Object of Study

One definition of the expression 'National Innovation Systems' is that which refers to a concrete system, that is where it is an object of study. It is that which the OECD refers to in the following collection of definitions from OECD (1999:10):

Box 1

National innovation systems: definitions

A national system of innovation has been defined as follows:

• " .. the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies." (Freeman, 1987)

• " .. the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge ... and are either located within or rooted inside the borders of a nation state." (Lundvall, 1992)

• "... a set of institutions whose interactions determine the innovative performance ... of national firms." (Nelson, 1993)

• " .. the national institutions, their incentive structures and their competencies, that determine the rate and direction of technological learning (or the volume and composition of change generating activities) in a country." (Patel and Pavitt, 1994)

• ".. that set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation

It is in this sense that one can read Freeman's use of the term as 'The British national system' or 'The United States national system of innovation'. In the same way, one can talk about 'Burkina Faso's innovation system' to refer to the system out there as an object that one can study.

2.2.1.2 National Innovation Systems as a Theoretical Concept

There is some uncertainty regarding the origins of the National Innovation Systems concept; even the writings of Freeman and Lundvall who are claimed to have developed the concept do not make its history obvious. While Freeman gives the credit for the first use of the expression 'National Innovation Systems' to Lundvall (Freeman, 1995), the latter, in his turn, attributes paternity of the concept to Freeman

(Lundvall, 2007). Nevertheless, the available literature supports a view that traces the first use of the concept back to an unpublished paper by Freeman in 1982 (Sharif, 2006). In this paper Freeman casually used the concept National Innovation Systems to highlight the key role that institutions play in innovation processes (Freeman, 1982). This shift from the Schumpeterian perspective on innovation in which the entrepreneur as an individual plays a key role in the innovation process is well expressed by Akrich and collaborators as follows:

> The bringing together of market and technology, through which both inventions *and* the outlets which transform them into innovations are patiently constructed, is more and more a result of a collective activity and no longer the monopoly of an inspired and dedicated individual (Akrich et al. 2002:189).

The NIS concept Freeman referred to was in fact a paraphrase of List's concept of 'The National System of Political Economy' coined in 1841 (Lundvall, 2007). As he stated, "the idea actually goes back at least to Friedrich List's conception of 'The National System of Political Economy' (1841), which might just as well have been called 'The National System of Innovation'" (Freeman, 1995:5). Later this concept received its first systematic treatment in 1985 by Lundvall in his book *Product innovation and user-producer interaction* (Lundvall, 1985). In this book, Lundvall first used the concept 'Innovation Systems' but without the term 'National'. According to the author, "a system of innovation is constituted by elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge…" (Lundvall, 1992: 2). The idea of 'Innovation Systems' was present in Lundvall and his colleagues' work in the IKE (Innovation, Knowledge and Economics Dynamics)[13] group from Aalborg University since the late 1970s during which time the group developed a distinctive approach to international competitiveness by integrating "a French structuralist approach to national systems of production with the Anglo-Saxon tradition in innovation studies to national systems" (Lundvall, 1992: xii).

Before the use of the concept of 'Innovation Systems' in 1985, the standard phrase of the group was 'innovation capability' of the 'national system of production" (Lundvall, 1985). There appears to be a similarity between the way Freeman found his inspiration from List and the way Lundvall connected his concept to the IKE 'System of Production' (Lundvall, 1985). The formulation of the full concept of 'National Innovation Systems' in its modern version has to wait until 1987 thanks to Freeman's book on Japan (Freeman, 1987). The large diffusion of the concept benefited from an edited book by Dosi et al. (1988) entitled *Technical Change and Economic Theory* in the framework of reflections at IFIAS (International Federation of Institutes for Advance Studies) on 'rethinking economic theory' (Sharif, 2006). In parallel, policy discussion was initiated at the OECD under TEP (Technology Economy Programme) which was launched in 1988 with the aim of integrating "science and technology policies into other aspects of government policy, particularly economic, social, industrial, energy, education, and man power policies" (Sharif, 2006: 751). Lundvall's and Freeman's reflections benefited from their interactions with colleagues at OECD (Chesnais) and in academic circles which included Smith, Dosi, Edquist, and Nelson. The OECD's report (1992) on the NIS together with

[13] The IKE Group is a research group at the Department of Business and Management. The group has evolved into a long-term research program in innovation studies, industrial economics, and entrepreneurship at Aalborg University

several key publications by Freeman and Lundvall (1988), Lundvall (1992), Nelson (1993) and Edquist (1997) have also contributed to the wide diffusion of the concept. In the OECD's report, the NIS is defined as:

> the set of institutions that (jointly and individually) contribute to the development and diffusion of new technologies. These institutions provide the framework within which governments form and implement policies to influence the innovation process, as such, it is a system of interconnected institutions to create, store, and transfer the knowledge, skills, and artefacts, which define new technologies" (Metcalfe in OECD, 1999: 24).

From this perspective, the innovation capacity of a country reflects its innovation system as derived from its firms' capabilities and networks, science system, supporting institutions, and other research bodies to the extent that they are the sources of the generation, diffusion and use of knowledge (OECD, 1999). Distinctively focussing on the level of the nation-state, the National Innovation Systems considers that the dynamics of these institutions are inter-related with the broader macro-economic and regulatory context (communication infrastructures, factor market conditions, product market conditions, education and training system) (OECD, 1999). The contributions of the individual institutions are not considered in isolation but "how they inter-act with each other as elements of a collective system of knowledge creation and use, and on their interplay with social institutions (e.g., values, norms, legal frameworks)" (Smith in OECD, 1999: 24). In this inter-action, the government has a key role through its policy options and regulations. In sum, Lundvall has identified three key variables which are government, universities (knowledge producers) and firms/industries/business actors (users of knowledge) (Lundvall, 1985; 1992; 2007). In fact, "Innovation and technology development are the result of a complex set of relationships among actors in the system, which includes enterprises, universities and government research institutes" (OECD, 1999: 7). As underlined by Goto, "The national innovation system essentially consists of three sectors: industry, universities, and the government, with each sector interacting with the others, while at the same time playing its own role" Goto (2000:104). The role of each of these is now explained in turn.

- **Government's role**

First, many of the innovation system scholars made explicit the fact that government should be actively involved (Freeman, 1995) in fostering innovation. The acquisition of the technology, its use and diffusion involve the government, whose role in the system is essential. Through its policy makers, the government plays a key role by making choices which inform strategies at national level (Freeman, 1987). Indeed, the government is considered as a lead actor that influences on the one hand the Foreign Direct Investment (FDI) because, "despite their limited size, FDI inflows have had a positive impact, as much as they generated employment in the formal sector and generated local value-addition" (Nations Unies, 2009:2). On the other hand, such a flow is supported within the framework of government IPR [Intellectual Property Right] regulation in which "processes are decomposed into three stages, innovation process, commercialisation process and IPR protection process" (Sudsawasd and Chaisrisawatsuk, 2014: 1). By designing the IPR system for the sake of business and government direct scientific research such as financing universities, supporting business Research and Development (R&D), "the Government has a responsibility to contribute to the formation of the human and social capital needed to evaluate, choose, implement and modify foreign technologies" (Feinson, 2003:23). R&D can be used for knowledge assimilation and national technological creation as shown by Freeman from his Japan case study (Freeman, 1987). The incentives created by the government are necessary to set these aspects at the level of national policy direction in order to provide administrative support as well as facilities and equipment for enhancing and legitimising networking between the producers and users of knowledge (Lundvall, 1985; Freeman, 1995; OECD, 1999). The commitment of the government, as well as specific actions to provide actors with such a context, is thus required in order to produce a favourable social and political context for networking between firms and knowledge producers.

- **Universities' role**

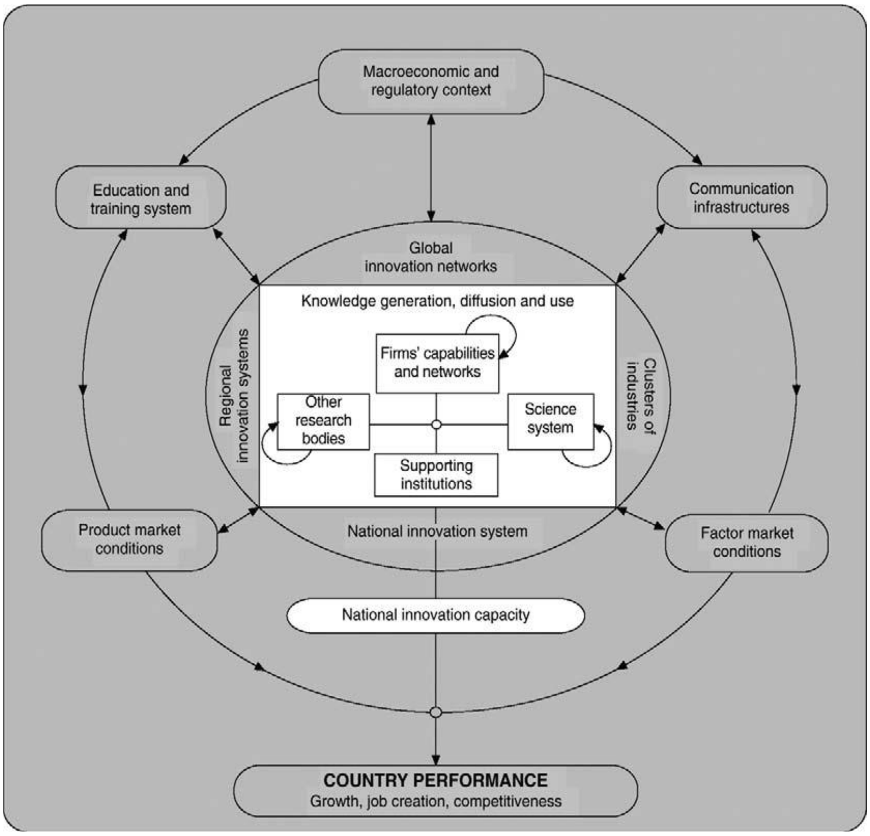
Second, the knowledge producers are also essential for the creation or invention of any innovation because the performance of the system depends on human capital and capability. These knowledge producers are produced by universities and technical organisations and schools, for example (Lundvall, 2007). Universities in particular have their own research units which play a facilitating role in the formation of the market by providing new knowledge and skills and by undertaking research (Lundvall, 1985; 2007; Freeman, 1987; OECD, 1999). These knowledge producers' institutes are centres for basic research and also scientific training (Lundvall, 1985; OECD, 1999). In other words, universities as knowledge producers undertake in this regard, basic science and technological research. At the same time, the universities provide higher education to scientists as well as technologists so that they can generate the innovation needed by both business and government. This role of the universities was also underlined by Nelson: "[Universities provide] higher levels of scientific training and the management skills to coordinate what is inevitably a multi-person or multi-firm affair" (Nelson, 1990 in Feinson, 2003: 24).

- **Industry's role**

The third important variable includes enterprises/firms/industries. They are all considered as business actors who are the users of the innovation created by the knowledge producers from universities and research centres (OECD, 1999). In the NIS, firms contribute to the diffusion of the market knowledge (OECD, 1999). The idea of a system whereby firms are in interaction with the two above variables was discussed by Lundvall (1992), Nelson (1993), and Edquist (1997). As demonstrated by the OECD (1999), business or industry does not function alone because government as well as universities are also integral parts of the system in the innovation process. As for the firms/industries, they are considered as business actors whose role is to conduct R&D for the purpose of developing products for commercialisation. They launch the different innovative products and exploit the new scientific discoveries (OECD, 1999).

The NIS framework is displayed as follow.

Figure 1: The conceptualisation of the NIS framework



Source: OECD (1999). Managing national innovation systems.

Paris: Organisation for Economic Co-operation and Development, p. 23.

As institutionalists, the founders of the NIS reject the way the mainstream economic theories consider knowledge, technology and technical change. In their publications, they criticized and rejected the orthodox economic theory for the study of innovation. They believe that the knowledge economy has a distinctive character and that only an institutionalist approach can uncover the role and the special character of technical change. The adjective 'national' is the way to underscore this institutional dimension of innovation. As Chesnais points out in an interview, it is 'national' because,

> we were saying 'national' when the trend was already saying governments must bow out…the importance was political, really and it became one of the

rallying flags for people who continued to say that national economics systems are not just markets, they are institutions, they are systemic relations, there are linkages (Chesnais in Sharif, 2006:753).

In relation to the academic origin of the concept, the analytical model the authors developed comprises the following key variables related to the above conceptual framework (figure 1):

Table 2: Key Variables of the NIS theoretical concept

Firms' characteristics	**Firms' interactions**	**Context of the NIS**	**Performance and characteristics of the NIS**
- Firms' mode of innovation ○ Organisational set-up ○ Human resources ○ Sector specialisation	- Local interaction among firms - International interaction among firms - Local interaction between firms and knowledge infrastructures - International interaction between firms and knowledge infrastructures	- National education system - National labour market - National financial market - Welfare regimes - Intellectual property regimes	- Innovation System specialisation and performance ○ Firms organisational positioning ○ Firms network positioning

Source: Process by author from: OECD (1999). Managing national innovation systems, Paris: Organisation for Economic Co-operation and Development, p. 24.

Based on this model, a number of case studies have revealed some empirical studies on successful uses of the NIS concept by other countries as ‘best practices’ in policy circles (OECD, 1999). Indeed, the NIS concept has influenced innovation practices and the OECD has evaluated such practices and on the basis of this established a ‘best practice’ guide for policy makers. These practices are perceived as standard for innovation for economic growth. Thus, every country aiming to use the NIS as a development tool for economic growth could follow these previously certified and tested standards. The NIS concept can be presented in its key aspects as follow:

Table 3: Standards indicators of the NIS theory

Firms characteristics		**Firms interactions**		**Context of the NIS**		**Performance and characteristics of the NIS**	
Characteristics	***Standards***	***Interactions***	***Standards***	***Structure***	***Standards***	**Performance and characteristics**	**Standards**
Firms' innovation		Local interaction among firms	-internet based business information network -Building networks between public research actors and firms	National education system	-reform post-secondary education -increase government and industry support to professional education -Technology foresight for policy	Firms organisational positioning	-making evaluation obligatory -developing new methodologies

			-Public-private partnerships -Building networks of competitive domestic firms --raising the co-ordination function to the highest policy level		setting. Regulatory reform (university-industry interface) -Systemic upgrading of the S&T infrastructure		
Organisational set-up		International interaction among firms	-internet based business information network - Building networks between public research	National labour market	-Brokering and procurement policies	Firms network positioning	-making evaluation obligatory -developing new methodologies

			actors and firms -Public-private partnerships -raising the co-ordination function to the highest policy level				
Human resources		Local interaction between firms and knowledge infrastructures	-internet based business information network - building networks between public research actors and firms -Public-private	National financial market	-establishment of legal framework for venture capital -Funding greater use of benchmarking and diagnostic tools. -Public investment in venture		

			partnerships -raising the co-ordination function to the highest policy level		capital -Co-financing of consultants to upgrade firms’ organisational ability -co-financing of technology uptake via public/private partnerships. -competition among regions for funding of cluster initiatives -co-funded centres of excellence to facilitate university-industry linkages		

					$$-Increase government spending on basic R&D -Increase public support to R&D		
Sector specialisation	-Building innovation clusters	International interaction between firms and knowledge infrastructure	-internet based business information network - Building networks between public research actors and firms -Public-private partnerships -raising the co-	Welfare regimes			

			ordination function to the highest policy level				
				Intellectual property regimes			

Source: processed by author from: OECD (1999). “Managing National Innovation Systems.” Paris: Organisation for Economic Co-operation and Development, p. 70.

During the diffusion process of NIS, there has been what Lundvall described as "some distortion of the concept [NIS]" (Lundvall, 2007: 2). From the 1990s, policy makers and scholars started to apply a narrow understanding to the NIS theoretical concept (Lundvall, 2007), leading to the emergence of other competing systems theories and studies about innovation systems. Among them are four theories which have attracted a following in academic and policy circles alike.

1) The 'Technological Systems' concept developed by Carlsson and Stankiewicz (1995). This is seen as a more dynamic approach, compare to previous ones, in which technological change depends on technological systems. Such systems include technical objects, natural resources, people, organisations, knowledge, legislations and norms (Carlsson and Stankiewicz, 1995).

2) The 'Regional Systems of Innovation' concept of Cooke (1996) has more characteristics in common with NIS. Indeed, in this perspective, as with NIS, knowledge is tacit and locally shaped (Lundvall, 2007).

3) Breshi and Malerba, (1997) have developed the concept of 'Sectoral Systems of Innovation'. This concept offers a multilevel integrated system and an active view of a specific sector. It is proposed by Malerba that "a sectoral system is a set of products and the set of agents carrying out market and non-market inter-actions [understood as interactions amongst people] for the creation, production and sale of those products. A sectoral system has a specific knowledge base, technologies, inputs and demand" (Malerba, 2002: 247).

4) More recently, the ‘Triple Helix’ was developed by Etzkowitz and Leydesdorff (2000). For the authors “the Triple Helix denotes not only the relationship of the university, industry and government, but also internal transformation within each of these spheres” (Etzkowitz and Leydesdorff, 2000: 118).

These systems theories recognised, as does the NIS, that interaction between users and producers of knowledge in a favourable political context leads to economic growth. All the systems approaches agree on something fundamental: the existence and importance of interactive characteristics. However, Lundvall (2007: 97) considered these approaches which emerged after the NIS as “crude interpretations and examples of misunderstandings” of what exactly the NIS theory incorporates and means. For him, the Innovation System concept is shaped by the local and national imprints given its national characteristic. Seen from this perspective, the sectoral innovation system, the regional innovation system, and the international innovation system are namely versions of the NIS theoretical concept. For Lundvall, “to compare sectoral, regional and technological systems across nations is often an operational method for understanding the dynamics at national level” (Lundvall, 2007:100).

In other words, the analytical concept of a National Innovation Systems began to take shape as a narrative for policy – a description of the rationale for a policy direction, and the elements making up policy tools and actions. There is a significant difference between the two. While the academic analysis retains qualities of openness and reflexivity in the search for understanding or exploration (depending on the epistemological approach), a policy narrative is associated with closed definitions and set assumptions, and is oriented toward outputs and outcomes.

2.2.1.3. National Innovation Systems as a Policy Tool

The NIS has also come to be associated with and defined in terms of policy rhetoric which can "provide policy makers a reasonably coherent "World View" and with basic principles of policy making on innovation in the new context" (Lundvall and Borras 1997:3). Thus, the NIS is used in policy circles as a rhetoric through which one can narratively frame policy. The objective of this use is practical -to enact policy and thus turn the NIS into what can be called a 'policy tool' in Lundvall's (2007:1) point of view. The use of the NIS as a policy tool is not as commonly known by academics as its use as an object of study or its use as a theoretical concept. Miettenen (2013) considers it as 'A transdiscursive term' (2013:18) because, for him, "it [is also] a political term uses by national and international (OECD and EU) policy makers" (Miettenen, 2013: 8). In the same way of thinking, Feinson (2002:14) mentions that

> the concept of National Innovation Systems (NIS) has been gaining […] practical coherence [policy tool] over a number of decades, enjoying initial strong adoption by OECD and developed countries, and more recently becoming the focus of increased attention as a means to address some of the more profound issues for developing nations.

As a result, policy makers view NIS as having prodigious descriptive power in terms of a source on how a country's economy develops, as well as a potential conceptual framework that can be used in order to design and produce policies and institutions capable of implementing innovation and boost the economy (Miettinen, 2002). Understood in this way, the NIS also "provide[s] the framework within which governments form and implement policies to influence the innovation process. As such, it is a system of interconnected institutions to create, store, and transfer the knowledge, skills, and artifacts, which define new technologies' (Sharif, 2004:84). This use of the NIS within policy circles is considered by Lundvall (2007:96) as the 'original agenda'. Godin (2009:17) sees such a role of the NIS as an 'umbrella concept'. He suggests that "the concept of knowledge based economy is simply a concept that serves to direct the attention of policy makers to science and technology issues [and the OECD is a] research think tank that feeds policy makers" (Godin, 2009:3). In other words, the OECD is the institutional frame within which the NIS was developed in order to provide countries with practical tools to help solve the economic crises they were facing.

For these reasons, this thesis accepts the proposition that the NIS is a tool for intervening in the economy for the purpose of development; indeed, Sharif, (2004) argues that:

> The concept arose simultaneously in academia and policymaking (with regards to the latter, specifically in the OECD) at around the same time. This was possible because many of the key proponents of the concept occupied roles in both academia and policymaking (Sharif, 2004:11).

Thus, the NIS is used by policy makers to design their policies. Originally, the concept was not only developed as an 'analytical concept' (Lundvall, 2007:1) for scholars to understand and explain innovation dynamics and countries' performances, but also as a 'development tool' (Lundvall, 2007:1) for policymakers as a means to promote growth, job creation and competitiveness. Miettenen (2013) believes that the idea of the innovation system was developed in the 1980s by researchers who were trying to formulate a useful concept for policy design.

The key aim in this thesis is to investigate two projects, the NIS inspired policy tool and the Bt cotton innovation system, in facilitating development in Burkina Faso at both strategic policy and operational levels. Indeed, for the specific case of Burkina Faso, a project was developed in 2006 by both the FRSIT (representing the government) and the IRDC that intended to introduce the NIS framework as a policy narrative in order improve what one might call the NIS of the country.

In doing so, they created a specific object of study – namely the Burkina Faso Innovation System – and applied to the existing ways that innovation has played as part of Burkina Faso's economic history.

2.2.2 Overview of the Burkina Faso Innovation System

Burkina Faso is a landlocked country in West Africa which was colonized by France from the early 1900s before becoming an independent state in 1960. Social, economic, political and historical reasons have shaped the innovation system of the country known as Upper Volta since the 1900s until 1984 when it became known as Burkina Faso. This section will briefly describe the existing innovation system of Burkina Faso before the introduction of the NIS project, in relation to three key elements: science, industry and the state.

- **Scientific research and its institutions**

The characteristics of the existing innovation system in Burkina Faso differed in comparison to the national innovation systems with regard to the roles of science, the key actors, the industry and the research and, most importantly, the role of the State within the system. Some accounts argue that scientific research in Burkina Faso began with colonization. It started with the Voltaic Centre of Scientific Research (CVRS), the nationalized name of the French Institute of Black Africa (IFAN) which was created in 1937 (IFAN, 1960). IFAN had its headquarters in Dakar and a branch located in Burkina Faso since 1949. It changed its name to CVRS in 1965 (Lill and Gaillard, 2013). Long before IFAN, the French set up the first experimental agricultural research Station of Saria in 1923 at Niangologo in the western part of Burkina Faso (Notes Africaines, 1961). Thus, science in French West Africa, specifically in Burkina Faso, was canalized and controlled by France to fulfil the immediate needs of French people. Jezequel (2007) considers the 1910s as the period which marked Africa’s entry into ‘research’. This period was characterized by some indigenous research and the institutionalization of training.

In addition, investment in scientific research and higher education in the colonial period was significantly weaker because this was not a priority for the colonizer. Therefore, indigenous research was partly motivated by the colonizer wanting to know and study that primitive society for better administration and exploitation (Notes Africaine, 1961). Basic knowledge was given to a small number of people. For example, the Institute of Black African Studies (IFAN) focused on human, social and natural sciences (Notes Africaines, 1961).

> In French–speaking Africa, the vast majority of authors were local schoolmasters trained at the prestigious Ecole Normale William Ponty in Senegal. Only a handful of these authors were officially recognised as such by either the colonial administration or the scholarly community. Thus while a few actually had careers as researchers, for the vast majority their ethnographic investigations boiled down to a few pages published in a local journal. (Jezequel, 2007: 145)

The result of the above processes was the development and creation of very few research and training institutions during colonisation. Ecole Normale William Ponty trained school teachers from 1910 until the 1950s in all French West African colonies (Notes Africaines, 1961; Jezequel, 2007). This was the first colonial training institute in addition to IFAN, the research institute (created on August 19, 1932) to which Burkina Faso was linked (Note Africaines 1961). The creation of the research centre (ORSTOM) contributed to scientific research and knowledge development in West Africa (Bonneuil and Petitjean, 1996). Thus, scientific research was slowly promoted and had begun finding its way by the late 1950s. This led to the conversion of William Ponty's school in Senegal to the University Cheick Anta Diop on the 24th February 1957 (IFAN, 1961). Later on, the research institute and the university both were reorganised and linked to each other as a system in order to enhance the development of scientific research. Scientific research in Upper Volta as a dependent colony began with Station de Saria in Niangologo in 1923 and the IFAN centre in Ouagadougou in 1949. But there was a mismatch between research and development activities and national industrial development strategies and goals.

Higher education in its modern meaning did not exist until 1970s after independence because there was an awareness of the need for a solid intellectual base for the consolidation of independence, as well as a means to meet the overwhelming requirements for high-level manpower (Yesufu, 1973). This awareness led different African countries to create their own national universities to promote higher learning in the 1970s. Among them was the University of Ouagadougou, the first and the biggest University of the country established in 1974 to create and teach new knowledge. Even with the creation of the university, research fields were limited to Ethno-sociology, Geography, History, Linguistics, Zoology, and Botany.

The agricultural sector was the most developed sector, more specifically the cotton sector was the most developed agricultural sector in terms of research and industry. Like the agricultural sector, the industrial sector was very weak in Burkina Faso.

- **Industries**

The industrial sector contributes 3% of the GDP in Burkina Faso, which remains very weak (Sidwaya, 2007, Tieba, 2016). As stated by one specialist, "We are almost exclusively dependent on the export of our raw materials. Well, cotton is, according to 2006 and 2007 report, nearly 70% of [the country export] exports." (Sylvanus Traoré in Sidwaya 2009: 2). This means there is a lack of industries to transform products before export. In terms of commodities, the country exports animals to Côte d'Ivoire, Ghana and Nigeria. These animals could have been turned into meat for a greater benefit. That is to say, "Many companies are craft industries" (Sylvanus Traoré in Sidwaya 2009: 2) with more focus on many SMEs mainly in the food sector.

However, “beside this, there are some major industrial companies that have made the country proud when they were under the control of the state before being privatized” (Sylvanus Traoré in Sidwaya 2009: 2). Among them is the cotton industry (SOFITEX). This industry, between 1900 and 1960, was based in France and known as CFDT, the French fiber company. From 1960, the independent state had no choice other than to continue the initiative of the colonizer by building up its economy on cotton. As can be seen, until 1990, the innovation system of cotton which benefited from specific research and industry had a functional innovation system. However, in general terms, until 2006, the industrial sector was still very weak and limited.

- **The state**

The role of the State at that time in the system was more or less absent. Indeed**,** Burkina Faso’s development policies[14] from the 1950s were shaped by the institutionalist model based on a “move to a higher technical and cultural stage” (Gerardin, 1964:111). As a result, the State did not encourage any development of highly educated people able to create new knowledge and technology for the industries. The impact on policy based on the critical perspective of modernization policy provided by dependency theory (supports the idea that the economies of the countries of the South are better understood within the international economic system) during the 1980s resulted in some substantial changes in the country’s socio-economic

[14] ‘Plan Triennal 1960-61-62’ [Three Year Plan 1960-61-62]; ‘Premier Plan Quinquenal de Development 1963-1967’ [1st Five Year Development Plan 1963-1967]; ‘Plan Cadre 1968-1970’ [Framework Plan 196801970]; ‘Plan Interimaire 1971’ [Interim Plan, 1971]; ‘Deuxieme Plan Quinquenal du Development Economic et Social 1972-1976’ [2nd Five Year Socio-economic Development Plan 1972-1976]; ‘Troixieme Plan Quinquenal du Development Economic et Social, Avant Projet 1977-1981’ [3rd Five year Socio-economic Development Plan 1977-1981]

development (World Bank, 1999). Higher education was promoted and endogenous research was the priority. However, this approach, which gave an active interventionist role to the state, was displaced by the market model at the end of the 1980s. Such a shift in policy led to some changes in the policy options through privatization of government industries such as SOFITEX. The State could not play the facilitator role in the context of a free market. In such a context, the Strategic Plan of Scientific Research of Burkina Faso, was developed in 1995 by policy makers, national and international scientists and specialists, aimed through the National Forum for Science and Technological Research (FRSIT) and the National Agency for Valuing Research Results (ANVAR) to adopt innovations able to support the country's development (Université de Ouagadougou, 2004). However, even with the development of higher education, the country was still facing serious difficulties due to the fact that research outcomes were not adequately disseminated to the industries.

- **Existing Linkages Between Actors**

Up to 2006, the innovation system in Burkina Faso was still weak (MRSI, 2012) despite the effort that the government and other related actors put into it. Indeed, like the different science policies since the 1960s, the existing institutions, enterprises and human actors were considered inadequate to promote innovation systems in Burkina Faso. In addition, they lacked government support. Thus, the existing linkages between the actors of the innovation system were either weak or did not exist at all. The innovation system as an interaction between users and producers of knowledge was not strong enough to bring about sustainable outcomes. The FRSIT was created and institutionalized in September 1995 (FRSIT/CDRI, 2008) to promote the use of research results and innovations at national and international levels, and to encourage research collaboration through biennial events. To fulfil these aims, The National Agency for the Use of Research Results (ANVAR) is the sub-structure created in 1997 whose task was to promote the use of research results generated in Burkina Faso, neighboring countries and worldwide (FRSIT, 2009). Pure research is still predominant compared to applied research. Up to 2006, the FRSIT has failed to bring users and producers together as a strong network to implement innovation for development in Burkina Faso (Nacoulma et al., 2005).

With regards to these difficulties the country, in relation to how to promote science, technology and innovation, to bring together users and producers of innovation, was looking for alternatives. Thanks to the long standing collaboration between (International Development Research Centre) IDRC and FRSIT who have been working together in order to solve this issue, a collaborative project was formulated. Indeed, they both came to the conclusion that there is a need for an interactive tool. In their search for a new and interactive framework to bring actors together in order to promote innovations and boost the country's economy, the NIS was proposed by IDRC as a tool to improve the country's developmental sectors through interaction between users and producers. Thus a specific project was put into place to adopt the NIS as a policy narrative to improve/transform the existing weak innovation system for socio-economic development.

2.2.3. Development

The concept of development has a long history and has given rise to considerable controversy (Rostow, 1960; UNDP, 1991; Escobar, 1991, 1992; Rist, 1997). Gilbert

Rist (1997), a specialist in development theory, offers the most comprehensive discussion about the concept, and as such provides the main source for the present conceptual discussion. According to Rist's historiography, the concept can be understood in three ways.

First, development, in its intransitive sense, can refer to a natural phenomenon of growth. This definition is reflected in processes such as growth from small to big, young to old, immaturity to maturity, child to adult, that is, humans, animals and trees grow physically and naturally. Referring to the evolution of western thought, Rist (1997) underlined that this natural development is thought to happen in three ways: 1) God's intervention, 2) spontaneity, or 3) just a natural phenomenon. This earlier conception of development has influenced the history of the concept. Considering western society as the highest stage of development, this definition came to scale the history of all societies as passing from savage to barbarism before reaching the stage of civilisation. Rist shows how such a conception underpins western imperialism, and is played out through colonisation. In this respect, development is seen to be synonymous with another term - civilisation.

Second, in its transitive sense, development is considered as a process with the objective of modifying a reality in order to improve it. Development conceived as process emerged in the 1940s. This is strongly connected with European colonisation and the fight for decolonisation. Indeed, colonisation is the beginning of the emergence of the difference between two different worlds: one is civilised and the other non-civilised. Such a distinction between the two worlds led to repeated invasions by the 'civilised world', which conquered the 'non-civilised'; this period of colonisation was “a transitional period, then in which brutal power relations existed alongside paternalist feelings of responsibility towards ‘natives’ who needed to be civilized” (Rist 1997:47). It was within this context that the concept of development as process enters policy circles. According to Rist, US president Truman first employed the concept in 1947. Since then and afterward, the concept has been widely used and promoted throughout academia and policy circles. Truman regarded development as a process, a way to help underdeveloped countries in their fight against poverty. This definition implies a purposive intervention, as is reflected in the following from the South Commission’s report that defines development as:

> a process which enables human beings to realise their potential, build their self-confidence, and lead lives of dignity and fulfilment. It is a process which frees people from the fear of want and exploitation. It is a movement away from political, economic, or social oppression. Through development, political independence acquires its true significance. And it is a process of growth, a movement essentially springing from within the society that is developing (Rist 1997: 8-9).

What is stressed here is both the purposive intervention and the endogenous character of any development which aims to be sustainable. Then, development consists of changing a reality by implementing activities. It is expected that these activities will result in a given desired state. Such a desired state is the third meaning of the concept of development. Studies in development studies have been generally concerned with this dimension of development. In this respect, authors such as Lipton (2005) underlined the contribution of biotechnology to the reduction of poverty. Biotechnology is seen here as a means to reach a desired state (development). As he stated,

> Family farming, crop science and 'globalisation' together largely determine progress against poverty […] and science-based rises in small farmers' staples food productivity, […] Most of the world's poor are in, or employed mainly on, family farms. Big gains for all main groups of dollar-poor need, first, a special type of growth in farm productivity; partly by luck, the Green Revolution was of the right type (Lipton, 2004: 1).

It is believed that crop science will alleviate poverty in poor countries. It is also believed that biotechnology will bring about development by increasing the quantity and quality of agricultural products, thereby increasing the income of farmers in developing countries and raising their living standards. For biotechnology proponents Bt cotton appears in this respect as a way for African's farmers to alleviate their poverty (2003; Glover, 2010). At policy level it is this understanding of development that underlies all technical cooperation for development (Gaillard, 1999).

Nonetheless treatments of development as intervention often ask questions about the impacts of such intervention. This aspect concerns the third meaning of development, which refers to a change from position A to position B (B being better than A) (Aron 2006). For example, developed countries contrast with underdeveloped ones, as each refers to a particular point in a rank. Aron claims that the objectives for all countries are the same; they all aim for higher economic growth. It is from this perspective that the differences between rich and poor countries become more observable. This way of seeing development reduces it to increases (or not) in productivity; development in reality consists in producing goods in increased quantities and also different products with enhanced processes. For example, tools changed from manual to machines and increasingly complex machines in order to increase productivity. Underdevelopment was therefore characterised by a low level of GDP. Low individual income is another consequence of underdevelopment.

Today, definitions of development are not limited to a simple reference to increases in GDP. Instead, the basic objective of human development is to enlarge the range of people's choices to make development more democratic and fully participatory. These choices are believed to include access to income and employment opportunity, education, health, a clean and safe environment (Rist, 1997). Such a definition of development which includes the second definition of the concept goes back to the 1980s. This should enable individuals to enjoy human, economic and political freedoms in a sustainable way. Thus, there was an awareness of the interrelationship between modernisation and the culture of people. Development became "a process of profound structural transformation-it cannot be simply imported" (Rist, 1997: 202). In other words,

> development is a process which enables human beings to realize their potential, build self-confidence, and lead lives of dignity and fulfilment. It is a process which frees people from the fear of want and exploitation. It is a movement away from political, economic and social expression. Through development, political independence acquires its true significance. And it is a process of growth, a movement essentially springing from within the society that is developing ...the base for the nation's development must be its own resources, both human and material, fully used to meet its own needs...Development has therefore to be an effort of, by, and for the people. True development has to be people-centred (Rist, 1997: 202).

From this standpoint, development becomes more than just an increase of income and wealth. It focuses more on individuals' wellbeing and freedom. This calls for a more critical assessment of the potential of technological intervention to improve the welfare of societies which receive it. This is another aspect which is strongly addressed by the literature in development studies. For example, with respect to biotechnology, authors point out that its potential as a new technology need to be related to its use by people; because to reach a state of development (quantitatively and qualitatively) with biotechnology, it will require some radical reforms which prevents small farmers from domination for the rise of the pro-poor farm science. The necessary reforms to be carried out if the green revolution has to alleviate poverty in developing countries has been discussed by other authors such as Scoones (2006); Chataway, (2005) and Glover, (2010). Indeed, in the literature there is commonly shared view that:

> Pouring money into science and technology however without recognizing institutional and systemic complexities associated with creating 'pro-poor' technologies is unlikely to deliver much for those farmers. Moreover, there are a range of economic and political contextual factors which further complicate efforts to put the technology to use for poorer farmers. (Chataway 2005:597).

In this connexion, with regard to the environmental aspect, while the use of GM crops may bring environmental benefits through reduced use of agricultural chemicals, there is concern that they also threaten environmental stability. A prominent concern is that cultivation of GM crops will lead to reductions in biodiversity. Biodiversity is essential for environmental stability, and is recognised as an essential resource base, valuable for food security and sustainable development. GM crops may push their wild relatives out of ecosystems. There is also the risk of horizontal gene transfer (transfer of the novel genetic trait to other plants), which could result in weeds developing insect resistance or herbicide tolerance. Or the genes may transfer to insects or bacteria causing them to take up resistance too. There is evidence to support these concerns. Increased use of glyphosate herbicides on tolerant GE crops has also promoted resistance in weeds. As Levidow and Carr (1997) underline:

> …herbicide-resistant crops will perpetuate or even increase agrochemical usage (e.g., BWG 1990). More fundamentally, some NGOs criticize biotechnology for taking agriculture further down a misguided route. It develops single-gene solutions for problems that derive from a monocultural farming system, designed on industrial models of efficiency [...] Levidow and Carr (1997: 33).

The critique of GM is typically limited solely to biotechnology in agricultural production and homogenizes ‘farmers’ instead of appreciating the myriad ways in which different classes of farmers organize their production and reproduction (Glover, 2010). Another weakness is the failure to address the ways in which changes to intellectual property rights and other regulatory issues might open up innovation in GM and related technologies to broaden both the range of GM crops available and their delivery and accessibility to various categories of farmers. Furthermore, indirect shortcomings of technological innovation, such as those risks arising from biotechnology agriculture, are virtually absent from economic assumptions. From a development perspective however, these aspects cannot be ignored in the investigation of benefits of scientific and technological innovation in agriculture. The best studies on the matter come from sociology, as illustrated by the cogent study by Kloppenburg (2005). Indeed, in *First the Seed, the Political Economy of Plant Biotechnology, 1492-2000,* the rural sociologist analysed the process of expropriation of farmers by capitalist enterprise through agricultural research and technological innovation.

> The disappearance of family farm, the concentration of farm ownership and production, the displacement of labour, the decline in the quality of food, the deterioration of the environment, the rise of the agribusiness, the marginalization of small producer, and the exacerbation of income inequalities in farming. (Kloppenburg, 2005:4).

He sets out to explain how the increasing subordination of agricultural science to capital has been achieved and addresses some of its complex effects. Traditional histories of science have emphasized chronological order as an organizing principle. For Kloppenburg:

> Technology does not necessitate. It merely consists of an evolving range of possibilities from which people choose. A social history of technology that explores beneath the appearance of necessity to illuminate these possibilities which technology embodies reveals as well the contours of the society that realizes or denies them (Kloppenburg, 2005: 8).

As a result, the aspiration to a development stage could fail if, in the case of biotechnology, environmental, safety, economic and technical issues are not taken into account.

In conclusion, three fundamental definitions can be applied to the concept of development: 1) development as a natural phenomenon of growth, 2) development as processes which necessitate human intervention (e.g. green revolution as a scientific discovery to foster development) and finally, 3) development as a state which is the outcome of such processes such as biotechnology innovation processes. For the purpose of the present research, the second and the third dimensions of the concept of development are going to be discussed throughout the thesis.

From the end of the 1990s, some have argued that to achieve development (as a state) there is a need to develop new types of economies based on knowledge within which the NIS policy tool and biotechnology were both a choice to fulfil the desire outcome (development). The shift is the knowledge based economy implementation is the subject of the next section.

2.2.4. Knowledge-Centred Development

Because of its failure, enthusiasm for 'market fanaticism' has given way to a new consensus that Stiglitz and his collaborators have called the 'knowledge-centred development agenda' (Cimoli, et al. 2009:557). The World Bank in its first report at the beginning of the third millennium acknowledged that "Poor countries—and poor people—differ from rich ones not only because they have less capital but because they have less knowledge" (World Bank 1999:2). 'Knowledge' has taken the place of 'capital' as a production factor. The knowledge-centred development approach conceives of:

> development as a process that links micro-learning dynamics, economy-wide accumulation of technological capabilities, and industrial development. Different knowledge and different national ‘political economies’, of course yield different patterns of industrialization. However, it happens that all the countries which are nowadays developed undertook relatively high degrees of intervention to support their accumulation of technological capabilities and the transformation of their organizations of production especially in the early period of industrialization (Cimoli, et al.2009:543).

Slowly taking off from the start of the current millennium, its establishment as a dominant discourse on development was prompted by the economic crisis of 2008 (Cimoli et al., 2009), which reaffirmed that the role of knowledge in the economy is as old as economics. Smith (1937), List (1885), and Schumpeter (1934) had all addressed this basic problem.

Similarly, the ‘development age’ was opened with the feeling of duty to “embark on a bold new program for making the benefits of our scientific advances and industrial progress available for the improvement and growth of underdeveloped areas” (Rist 1997:71). The institutionalist model which was promoted particularly by Rostow (1960) made technological progress the key to the diversification, specialisation and modernisation of economic sectors. The dependency model of development embraced by a large number of countries in the South were attempting to de-link from international systems in order to benefit more from the science and technology that they expected would result from a package of endogenous policy strategies. The UNESCO information policy in the early 1990s provided a framework for these initiatives. The period between the late 1970s and the late 1980s saw the development of the first science and technology policies and the erection of higher education institutions in many countries in the South and in Africa in particular (World Bank, 1990). However, the institutionalist development regime developed earlier in the introduction of this thesis,

> the role of learning (how to discover, how to identify opportunities and constraints, etc.) and the product space literature highlight the role of capabilities in defining the direction of diversification. They fail to address the process of learning and the link between structural transformation and accumulation of capabilities. Learning itself and the evolution of capabilities remain in a black box (Nübler 2011:7).

In other words, “The thrust of institutional economics in the catching up debate is on the productivity-enhancing role of structural transformation” (Nübler 2011:7). Catching up is defined as a process of diversification into higher productivity and value added activities, and of enhancing the complexity of economic structures and sophistication of the production and export structure’ (Nübler 2011).

In 1990, African states developed their own strategic plans, with the support of the UNESCO fully-fledged program, which terminated in 1994. The strategic position of the World Bank gave it the power to shape the initiative to fit the market paradigm, resulting in it prescribing for the states a program of internal reorganisation aiming to boost African countries’ economic development (Nübler 2011:5). This was consistent with the structural adjustment policy, which prescribed liberalisation and squeezed the role of the state and social sector, including higher education. For the first time the Burkinabe government in the 1990s defined strategic lines of scientific research which enumerated the country’s development sectors, including: (1) more independence in doing and organising research; 2) the linking of all research programmes to social and contextual realities and needs; and 3) the linking of research activities to productivity. The 5-year strategic plan for scientific research in Burkina Faso set out in 1995 to both actualise the potential of research to contribute to the country's development and make the main research centre (CNRST) a tool and means to promote and coordinate research in order to realise the State's objectives (CNRST, 1994, 1995). It was considered that research should contribute to solving local and immediate economic and social problems, and that external financial support, although costly, remained very necessary. However, the World Bank kept a hold on the training of technical staff for government and training for private actors while building its own knowledge bank, anticipating or implementing a commercialisation policy of expertise in development techniques, which it considered would become the most important activity.

The prospect of a knowledge economy animated several debates towards the end of the 1990s, but it was particularly after the economic crisis that the knowledge-centred development paradigm found its opportunity (Rist 1997; World Bank, 1999; Cimoli et al., 2009). What is distinctive about the knowledge-centred development policy is that "Learning is viewed as the essence of development and the major rationale for industrial policies is to facilitate and shape the learning process for a rapid accumulation of domestic capabilities" (Nübler 2011:9). Over the last fifteen years, this regime has moved increasingly to the centre of the development agenda. Knowledge-centred development is realised through innovation. The challenge then for all states is to find the best approach for catalysing innovation for sustainable socio-economic development. The National Innovation Systems framework is one of the approaches for this process of change.

2.2.5. Social Technologies

The adoption of the NIS as a policy narrative and a policy tool in Burkina Faso can be seen as a case of technological transfer. Yet, to consider the NIS policy tool as a matter of technology and then investigate its transfer in Burkina Faso requires a broader definition of the concept of technology that goes beyond its traditional understanding. In this traditional sense, as Ellul pointed out, “Whenever we see the word technology or technique, we automatically think of machines. … we commonly think of our world as a world of machines” (Ellul, 1964: 3). Understood in this way, technology would be confined to its material aspect as associated with tangible products (e.g., tangible artefact, systems, and networks, etc.). Certainly, “the machine is the most obvious, massive, and impressive example of technique, and historically the first.” (Ellul, 1964: 3). However, reducing the concept of technology to its material aspect is misleading, because such a definition would exclude social relations and social practices (e.g., organisation of work), or knowledge, skills and techniques (Ellul, 1964; Sharif, 2004) that help shape and are shaped by technology., In other words, as Sharif put it cogently,

> …the definition of technology is one where technology has three parts. First are artefacts, systems, and networks. This is the material aspect of technology, and this is the traditional definition of technology associated with tangible products. Second are knowledge, skills and techniques…. The third component of technology is related [to] social practices and social relations (e.g. organisation of work) (Sharif, 2004: 89).

The NIS policy tool is thus not restricted to material technology of a tangible nature; but it is a social technology of the kind of ‘knowledge, skills and techniques’ or ‘social practices and social relations’. Therefore, as “a way of analysing an economy to determine how innovations can be promoted (for the purposes of economic growth)" (Sharif, 2004: 89), the NIS policy tool can be studied in the same way as STS approaches do for tangible artefacts. For example, the domestication of the scallops at St Brieuc Bay in France (Callon, 1986) entailed a transfer of social technology[15], raising similar problems (the social context such as the actors and their needs) as the diffusion of bicycles studied by Pinch and Bijker, (1984). As with any technology, the NIS is not neutral; it is embedded in the social context within which it is developed. This social context is not necessarily the same in the context of adoption. This socially-constructed character of technology raises a series of questions regarding the challenges that the social context of Burkina Faso poses in relation to the adoption of NIS too for innovation diffusion to improve existing innovation systems.

STS approaches have usually been used for the analysis of things that are more technical/tangible, however we believe the NIS, as an example of an intangible technology, is a model which can be studied. It can be used to explore non-tangible technology of the kinds of NIS policy tool adopted in Burkina Faso to implement knowledge-centred development policy regimes centred on innovation. Such hybrid networks such as the NIS have been categorised as 'social technologies' in recent studies (Sharif, 2004).

[15] It is about understanding the heterogeneous processes of social and technological change, focusing on the dynamic networks of actors and intermediaries involved in the production, use and diffusion of a new technology. Callon explores the way the networks converge, leading to unified links. The TENs' approach is therefore used to analyse coordinated sets of heterogeneous actors (human actors and intermediaries) which interact more or less successfully

2.3. Literature review

The question in hand here is how policy rhetoric/narrative/tools such as the NIS emerge and how this leads to a redirection policy making, which becomes institutionalised and implemented in development sectors. In other words, human action depends on the context, and presents some specific characteristic in relation to the context. Thus, policy formulation and policy implementation are shaped by their social context, and this is the case in relation to the use of the NIS policy tool when it is translated for use at policy and implementation levels. In such processes, the motives for action are different from one actor to another.

In this regard, the constructivist approaches in STS became relevant here. The pattern in these approaches can be seen as a reflection of the shaping character of the socio-technical milieu of technological practice (Sharif, 2004). The National Innovation Systems policy narrative (an intangible artefact) can be studied in the same way STS is for tangible artefacts. The studies by Callon and Bijker offer practical suggestions for this study. For Callon, Actor Network Theory (ANT) "consists of four moments which can in reality overlap. These moments constitute the different phases of a general process called translation, during which the identity of actors, the possibility of interaction, and the margins of manoeuvre are negotiated and delimited." (Callon and Blackwell, 2007: 59). Such a detailed set of steps is essential to the investigation of the implementation process of the NIS. In the same perspective, Callon developed the idea of Techno-Economic Networks (TENs) which focus on the dynamic networks of actors and intermediaries involved in the production, use and diffusion of a new technology. Through this he explores the way the networks converge, leading to unified links. The TENs approach is therefore used to analyse coordinated sets of heterogeneous actors (human actors and intermediaries) which interact more or less successfully. It is important to underline that as in the NIS, actors in TENs are independent.

Bijker shows how the Social Construction of Technology (SCOT), another constructivist analytical framework, supports the idea that human action shapes technology and vice versa. In other words, the way society is organised impacts on the way technology is developed and used. The proponents of this approach also argue that the ways in which a technology is used cannot be understood without understanding how that technology is embedded in its social context (Bijker et al. 2012)

The constructivist approaches such as TENs, ANT, SCOT all give significance to social and political factors. These analytical frameworks therefore offer in this respect a theoretical foundation for the present research because these constructivist approaches highlight that, as in the NIS, both science and technology are matters of social negotiation. Thus, an empirical study needs to be able to take into account the socio-cultural and political situation of the social group which shapes its norms and values, which in turn influence the meaning given to the artefact and how the artefact influences them in turn (Bijker et al, 2012).

From this perspective, authors have conducted their studies to focus on the process of the implementation of the NIS policy tool using constructivist approaches. Indeed, Sharif (2004) has demonstrated the 'contributions from the Sociology of Technology to the Study of Innovation Systems'. He demonstrates in his paper the extent to which

SCOT is a useful framework for the study of a National Innovation System as a policy tool. The main argument that he highlighted is that SCOT would help to understand the innovation systems by analysing a variety of social, political, cultural, environmental, and economic matters “surrounding the development of the concept as an analytical tool” (Sharif, 2004:90). In other words, as he puts it: as an ‘analytical tool’, the NIS can benefit from:

> a social construction of technology (SCOT) analysis. One of the main reasons for this is that the IS concept (as a social technology) is open to interpretive flexibility. The workability of the IS concept is subject to radically different interpretations which are coextensive with social groups. Different social groups apply this IS concept differently. Depending on which social group uses the IS framework (government, policymaking / influencing bodies, firms), different outcomes can accrue (depending on how they apply it). SCOT is valuable as it focuses attention on what counts as a viable working technology… (Sharif, 2004:90).

Additionally, Sharif has demonstrated that the actor-network theory framework is one with only a cluster of actants where it is possible to “break down the barrier between micro and macro level concepts and events by linking them together” (Sharif, 2004: 94). Sharif therefore credits ANT as also suitable for the analysis of the NIS. He claims that Law’s (1992) and Callon’s (1986) analyses are also applicable to the innovation systems development tool. Sharif did not limit himself to proposing STS approaches as suitable for the study of the National Innovation Systems model. He also conducted an empirical study using the NIS model (policy tool) in Hong Kong (Sharif, 2009), in his ‘*Rhetoric of Innovation Policy Making in Hong Kong Using the Innovation Systems Conceptual Approach’*. Based on the constructivist approach, Sharif came to the conclusion that the IS of Hong Kong has little to do with the IS frame developed by its originators in the 1980s. The author suggested that Hong Kong policy makers have used the IS tool in ways that diverge from its conceptual approach. Such flexibility, according to the author, makes its worldwide use possible (Sharif, 2006; 2009). In addition to Sharif, Cambrosio et al. (1990) have used the input and output measures from STS as their main analytical tool, accepting through this strategy the view that most studies treat science policy as a 'black box': hence their study attempted to analyse the actual day-by-day processes of science policy definition and implementation in the Quebec context. Before these authors' studies, only a limited number of people had studied in detail the construction and application of particular science policy programmes. In order to retrace such a construction process, ANT has been used as a suitable theoretical framework for examining the translation of biotechnology which is a concrete case study of science policy episodes intended to look not at why it happens but most importantly how this translation has developed.

The result of their analysis shows that policy definition processes are different due to administrative cultures and different governments' specificities in the way they shape innovation processes. This clearly highlights the extent to which innovation policy is culturally embedded in connection with the local nature of practices. In the same perspective, Albert and Laberge (2007), in *'The legitimation and dissemination processes of the innovation system approach: the case of the Canadian and Quebec science and technology policy',* reveal that their study draws its theoretical framework from Drori et al (2003) on the notion of cultural authority of science. Such a framework is developed through two interconnected phenomena: 1) that in modern society, science is seen as a main rational cultural framework - that is to say, that science structures and shapes the way modern societies view the world; and 2) that science is believed to be able to provide rational interpretations of the social and natural world orders from the larger political, economic, and environmental domains to the individual, taking into account personal behaviours and individual or groups practices, such as healthy lifestyle and parenting. In the paper, the authors argue that science acquires cultural authority through social actors' adherence to a 'scientized' view of the world. This cultural authority of science creates an increased demand for scientific knowledge. Their findings showed that the high level of adherence to the IS tool by public sector employees can be largely explained by the prestige, or symbolic power, of the OECD and its associated epistemic community, as well as by the cultural authority that science exerts on them (Sharif, 2009). These empirical studies have taken into account the socio-cultural and political situation of the social groups which shape its norms and values, and which in turn influence the meaning given to the artefact (in this case the NIS model).

However, as Cozzens (2002) and Geels (2007) have demonstrated, there are very few scholars who studied in addition to the process, the outcome derived from such a process in the implementation of science and technology. As Cozzens (2002:101) observed more than a decade ago, "the majority of [the literature] has studied the process of innovation and not its outcomes. Traditional innovation studies still focus narrowly on making new things in new ways, rather than on whether the new things are necessary or desirable, let alone their consequences for jobs and wages" Similarly, Geels pointed out:

> The sectoral systems of innovation approach has a strong focus on the development of knowledge, and pays less attention to the diffusion and use of technology, impacts and societal transformations. Sometimes, the user side is

> taken for granted or narrowed down to a ‘selection environment’. Hence I propose a widening from sectoral systems of innovation to socio-technical systems. This means that the fulfilment of societal functions becomes central (e.g. transport, communication, materials supply, housing). This indicates that the focus is not just on innovations, but also on use and functionality (Geels 2007:898).

There is an urgent need for a more comprehensive framework that not only takes the process aspect into account, but is also capable of integrating an account of outcomes. In other words, the constructivist approaches are limited to the understanding of development as a state or ‘as social kinds of goal-orientated action’ (Knight, 2008:317). This specific societal reality could be found in the case of the NIS which is a social technology, is shaped by human, economic and environmental context because, even in a context where rules exist to regulate actors’ actions, “a practice cannot be sustained if its participants do not normally act in accordance with its rules”, because, “those rules may be broken” (Knight 2008:318). Taking this aspect into account, it is particularly relevant to understand the outcome from the translation and also from the implementation of the NIS, drawing on the case of the introduction and impact of Bt cotton in Burkina Faso. This is particularly important in order to understand the exact aim of the involved actors through their actions and behaviours; because as can be seen with the previous development models, policy-makers can adopt a specific development strategy for financial support purposes, with a subsequent downgrading of development as the prime concern. This possibility is confirmed by Sharif’s finding regarding Hong Kong, which he qualified as, ‘a rhetoric of innovation policy making’ (Sharif, 2009). It is what Albert and Laberge (2007) also found through their case study on Quebec, Canada, where the adoption of the IS approach by public sector employees can be largely explained by the prestige or symbolic power of the OECD. In this case the symbolic power has overshadowed the goal of the policy practice.

To date the majority of the constructivist approaches that I reviewed above (ANT, TEN, SCOT) have shown a certain limitation in their ability to be used for the analysis of the outcomes derived from the implementation of a model/technology. The best, which is capable of combining both dimensions namely 1) the shaping and 2) the outcome from such shaping, is Frank Geels' Socio Technical-Systems (ST-Systems) or Multi-Level Perspective (MLP) framework. In the following I shall explain why it is best suited as analytical framework for my thesis.

2.4. Using ST-Systems approach to study the adoption, implementation and impact of the NIS as a policy narrative in Burkina Faso

There is a need for an analytical framework which in addition to what ANT, TENs, and SCOT have contributed in terms of the construction of networks can also locate these within broader socio-economic structures – such as the national systems of innovation described above. Geels (2004), a specialist in innovation systems and sustainability, therefore proposed:

> Look[ing] at socio-technical systems which encompass production, diffusion and use of technology, I define ST-Systems in a somewhat abstract, functional sense as the linkages between elements necessary to fulfil societal functions (e.g. transport, communication, nutrition). As technology is a crucial element in modern societies to fulfil those functions, it makes sense to distinguish the production, distribution and use of technologies as sub-functions. To fulfil these sub-functions, the necessary elements can be characterised as resources.

> ST-Systems thus consist of artefacts, knowledge, capital, labour, cultural meaning, etc. (Geels 2004:900).

Within the various STS approaches, the S-T Systems approach is more relevant to understanding the outcomes of a technological innovation. This approach originated from Geels, who argues that:

> Socio-technical systems do not function autonomously, but are the outcome of the activities of human actors. Human actors are embedded in social groups which share certain characteristics (e.g. certain roles, responsibilities, norms, perceptions). In modern societies many specialised social groups are related to resources and sub-functions in ST- Systems (Geels 2004:900).

From this perspective, the ST-System approach therefore drew from existing approaches in STS (ANT, SCOT, NIS) to capture technological processes that, considered individually, are not adequately addressed by the existing array of approaches.

2.5. Socio-Technical Systems

The ST-Systems shares some features with TENs, ANT, SCOT and the NIS framework. The emphasis on the 'national' context reflects a tacit recognition of the insufficiency of the potential of market mechanisms 'for stimulating accelerated rate of technical innovation and deriving the benefits from knowledge accumulation at the level of organizations and individuals' (Sharif 2005:84). At the same time the efficiencies of organisations and individuals:

> depends on numerous and often country-specific institutional, infrastructural, and cultural conditions with respect to relationships among the science, education and business sectors, accounting practices, corporate governance structures, and labour relations (Sharif 2004:84-85).

This conceptual move from the linear model, where the state is absent, led to the integration of the government as a key actor in the system. Indeed, "governments are seen to have a responsibility for improving the institutional framework for knowledge exchange among organizations and between market and non-market organizations in addition to correcting market failures (e.g., providing public goods, intellectual property rights, subsidizing R&D)" (Sharif 2004:85).

Another element around which the ST-System approach meets the NIS framework is the use of the metaphor of 'system'. Like the ST-System approach, the NIS:

> [A]llows emphasis to shift away from the organization as the sole vector of technological innovation in a society to the role of government policy, legal institutions, education and training institutions, and even norms and regimes. That the interactive processes and feedback loops between these institutions are emphasized is a strong point of the framework (Sharif 2004:87).

This institutional component is particularly emphasised by Geels (2004), who gives it a deeper conceptualisation compared with its discrete status in the NIS framework. Porter and Whitley's work on innovation and in particular Whitley's study of national business systems, which focused on the culturally embedded character of business practices, contributed to this strong attention to institutions. For Geels, drawing on a Mertonian insight, "the articulation of medium range patterns and stylized conceptual models may enhance STS's policy relevance, especially if they address issues that policy makers struggle with" (Geels 2007:630).

Geels adopted the Sectoral Innovation System and then extended it into the more specific "Sectoral Innovation of Socio-Technical Systems" (Geels 2007:898), in which the 'fulfilment of societal functions becomes central' (Geels 2007:898). This received less attention in the conceptualisation of Sectoral Innovation Systems (Geels 2007). By doing that, he therefore took part in an old debate among NIS analysts. Indeed, several scholars questioned the use of 'national' innovation systems, at different levels of analysis - such as technological, regional sectoral or trans-national - might be more appropriate. The move instead for the notion of system since the 1990s by some authors, such as Carlson et al (1995) ('technological systems') and Malerba ('sectoral systems of innovation'), as alternatives to the concept of national innovation approach shows the existence of the debate prior to Geels. This reflects the need for 'emphasizing the systemic characteristics of innovation but with focus on other levels of the economy than the nation state' (Sharif 2005:91). The argument is that with respect to modern innovation, interactions of significant relevance tend to take place across borders. Nevertheless, some contend that "Innovation systems also exist at other levels, *e.g.* there are world-wide, regional or local networks of firms and clusters of industries. These systems may or may not be confined within a country's borders, but national characteristics and frameworks always play a role in shaping them." (OECD 1997:23).

It appears, from these similarities, that what is distinctive about the ST-Systems approach is its aim to contribute to the analytical and instrumental improvement of the NIS rather than questioning the relevance of the content of the framework. And this contribution, which is of particular interest to this thesis, is to provide an answer to the question 'how do new sectoral systems emerge, and what is the link with the previous sectoral system. Geels gives his multi-level, ST-Systems perspective a coherent content that enables the understanding of socio-technical transitions, shifts from one socio-technical system to another at the level of societal functions (Geels 2007). He addresses the theoretical problem at the landscape level and at institutional levels. For him the shifts do "not only involve artefacts, but also infrastructures, regulations, cultural changes, mobility patterns and markets" (Geels 2007:641). In this perspective, Geels strongly supported the idea that:

> *Landscapes* provide even stronger structuration of activities than regimes. This does not necessarily mean they have more effects than regimes, but refers to the relationship with action. Landscapes are beyond the direct influence of actors, and cannot be changed at will. Material environments, shared cultural beliefs, symbols and values are hard to deviate from. They form 'gradients' for action (Geels, 2004:913).

The ST-Systems framework is appropriate for study because it takes into account processes such as translation (diffusion of NIS and Bt cotton), and collaboration systems analysis (NIS and Bt cotton innovation systems)), which makes it more relevant for this thesis, particularly with regard for example to the shift from a conventional cotton system to the Bt cotton system in Burkina Faso. As Freeman and Louçã (2001) suggested, "It is essential to study both the relatively independent development of each stream of history and their interdependencies, their loss of integration, and their reintegration" (Freeman and Louçã (2001) cited by Geels 2007:127). Nonetheless, if Geels has been able to achieve this theoretical improvement, it is thanks to detailed historical studies, which lead to an understanding of differences between periods of what, as well as drawing from the broader constructivist approaches such as SCOT, and ANT. The S-T Systems is:

> [A] process theory instead of variance theory. Ad 1) Transitions are enacted by different social groups. Ad 2) Actors change their perceptions of interests, preferences, and identity during transitions. Ad 3) the timing of events and multi-level linkages is important, influencing the type of transition pathway. Ad 4) Explanations in the MLP are layered and involve the tracing of twists and turns and alignments of event sequences and trajectories. Ad 5) The MLP has generality because it is versatile and maintains its basic character in different case studies and transition pathways (Grin et al., 2010:8)

The global explanation provided by the Socio-Technical Systems is about alignments and linkages between different processes. Within levels this explanation follows socio-technical logic, investigating interactions between heterogeneous elements and actors (weaving a seamless web) (Grin et al., 2010). The focus is on co-evolutionary[16] interactions between ongoing trajectories: developments in one trajectory (e.g. regulations) may hinder or stimulate developments in another trajectory (e.g. technology or markets). Positive and negative feedback play a role here. Between levels, the explanation is evolutionary, in the sense that the diffusion of niche-innovations depends on ongoing dynamics in the broader societal environment (regime and landscape). Selection is multi-dimensional, because it not only involves markets, but also regulations, cultural and social movements, infrastructure and legitimacy. So, evolution is a linkage process, which consists of making alignments between niche-variations and the constraints of societal selection environments (Grin et al. 2010).

Last but not least, what the ST-Systems approach can do that the constructivist approaches cannot is to suggest a clear way for addressing the outcomes of technological innovation for those who use it. With regard to this contribution of the ST-Systems approach, Geels suggests that:

> The first contribution is to include both the supply side (innovations) *and* the demand side (user environment) in the definition of systems. The sectoral systems of innovation approach has a strong focus on the *development* of *knowledge*, and pays less attention to the *diffusion* and *use* of *technology*, impacts and societal transformations. Sometimes, the user side is taken for granted or narrowed down to a ‘selection environment’. Hence I propose a

[16] The process by which 2 or more interaction species evolved together

> widening from sectoral systems of innovation to socio-technical systems. This means that the fulfilment of societal functions becomes central (e.g. transport, communication, materials supply, housing). This indicates that the focus is not just on innovations, but also on use and functionality (Geels 2007:898).

The ST-Systems approach is a relevant conceptual framework because it derives from, and builds upon, the three main approaches usually used to explain the systemic and collaborative aspects of innovations: the Sectoral System of Innovation (Malerba, 2002), Technological Systems (Carlson, 1997) and Large Technical Systems (Hughes, 1987) (Geels, 2004). The merit of Geels' work has been to derive from these individual approaches an integrated analytical tool which goes beyond discrete categories, to further understand the issue of dynamics. He views it as an integrative framework in innovation studies which includes users in the process, previously neglected by existing frameworks. In particular, Geels made four main contributions of relevance to investigating technological transitions and innovation benefits distribution which would be of use in investigating the present case study.

The first concerns understanding the processes through which the need for a new technology develops, which the above theories (ANT, SCOT, NIS) do not adequately integrate. In other words, the above theories felt it unnecessary to include such detail. Geels uses two related notions to characterise this process. On the one hand, there is the notion of the "socio-technical landscape", which includes "material environments, shared cultural beliefs, symbol and value". This also depends on the regime, a concept that will be explained below. Geels argues that:

> the transition [from niche level to regime level] occurred as a shifting mosaic of elements, as changes building upon each other, and processes gradually linking up and reinforcing each other [.…] New opportunities opened up which guided actors in different directions (Geels, 2002:1272).

On the other hand, there is the concept of ‘technological niches’, defined as “a loosely defined set of formal and informal rules for new technological practice, explored in societal experiments and protected by a relatively small network of industries, users, researchers, policy makers and other involved actors” (Geleen, 2005:48). This means that niches are places where solutions are developed for practical problems created by the landscape’s pressures. As Geels put it, “The work in niches is often geared to the problems of existing regimes […]. niche-actors hope that the promising novelties are eventually used in the regime or even replace it” (Geels, 2004:913). This contribution of Geels is a scene setting which helps to provide context including**,** landscape, regime and niches, which are important in new technology adoption. What is important is to explore the pre-existing system of the NIS framework in order to draw the niches and the possibilities of adopting the NIS framework to meet previously unmet needs. Before the discussion on Geels’ second contribution, it is important to give some detail on these relevant key concepts (Landscape, Regime and Niche), which provide the framework for the identification, collection, organisation and analysis of data in relation to the NIS framework.

a) Landscape (Macro) refers to the overall socio-technical setting that encompasses both the intangible aspects of social values, political beliefs and world views and the tangible facets of the built environment including institutions and the functions of the market place such as prices, costs, trade patterns and incomes (Geels, 2004, 2007). These processes occur within the wider political, cultural and economic background termed the socio-technical landscape. The landscape is an external backdrop to the interplay of actors at the regime and niche level. Changes can occur in the landscape but much more slowly than regime level. One such change is the increase in environmental awareness. This socio-cultural process is leading to pressure on numerous regimes (aviation, agriculture etc.) whilst providing openings for new technologies to establish themselves. The Multi-level Perspective presents the interplay between regime, niche and landscape concepts as a multi-level perspective depicting technological transitions. The model is heuristic rather than ontological, and is an aid to better understand the process. The model proposed by Geels shows how the success of a new technology requires developments across all levels to support the processes occurring within the niche.

b) Regime (Meso) refers to the dominant practices, rules and technologies that provide stability and reinforcement to the prevailing socio-technical systems. For him, taking the example on a case study (Geels, 2006), technological regimes are defined as a set of rules embedded in an engineering community's institutions and infrastructure which shape technological innovations. Geels also includes a wider range of social groups such as policy makers, financiers and suppliers. This web of inter-linking actors, following a set of rules was termed 'socio-technical regime', in effect, the established practices of a given system. Drawing on evolutionary economics, socio-technical regimes act as selection and retention mechanisms, filtering out the unsuccessful while incorporating more worthy innovations into the existing regime.

c) Niche (Micro) is the level or 'area' at which the space is provided for radical innovation and experimentation. This level is less subject to market and regulation influences and can facilitate the interactions between actors that support product innovation. Radical innovations occur in niches, which act as safe environments in which breakthrough developments can grow, sheltered from the selection process that occurs at regime level. A regime may host a range of niches which generate innovations to challenge the status-quo. The military is seen as a primary niche for major technologies of the last century, supporting the development of radio, aircraft, computers and the internet. The framework of support provided can be financial (most early ventures being commercially unviable); establishing learning processes and facilitating the social networks that lead to growth.

In the article where he analysed the breakthrough of rock ‘n’ roll (1930–1970), Geels (2007) showed how the transition to rock ‘n’ roll came about through mosaic elements of landscape, regimes and niches, and how technical and social elements, e.g. radio sets, record players, jukeboxes, record companies, radio stations, advertising schemes, recording technologies and studios, radio programming, airwave regulations are all in interaction. In addition, in another article, Schot and Geels, (2008) analysed the long-term innovation policies and development trajectories of four renewable energy technologies: wind energy, biomass, fuel cells and hydrogen, and photo-voltaics. He described the innovation journey from 1970 to 2006. This journey was characterised by a number of niche-level occurrences, such as failures, setbacks, hype and disappointment cycles, tensions, and struggles. In another study with Raven, Geels again discussed the innovation trajectory in Denmark's biogas development 1970-2002. They demonstrated the dynamics and interaction of emerging technological trajectories in the pre-market phase (Geels and Raven, 2007). So far most of Geels' case studies are about historical innovation shifts which describe how the innovation came about and what trajectory it took to be introduced within the context of landscape, regimes and niches.

Geels' second major contribution concerns the regime of actors involved in ST-Systems which relates to the perceived weakness of TENs, ANT, NIS/SIS and to some extent SCOT. Either the identification of the problems or the definition and development of solutions engage actors. As demonstrated by Geels (2002, 2004, 2007), the ST-System does not function automatically but is rather the outcome of human actors and institutions who usually belong to different social groups which share certain roles, responsibilities, norms and perceptions. Geels' (2002, 2004) suggestion is that the users' side needs to have a proper place in the analysis. In addition to the users with recognisable roles in the process, there is a need to consider, as Pinch and Bijker (1986) suggest, other less obvious social groups, such as those opposed to the technology. It is this heterogeneous network of actors that Pinch and Bijker (1984, 1986) call "relevant social groups". This notion "is used to denote institutions and organisations […], as well as organized and unorganized groups of individuals. The key requirement is that all members of a certain social group share the same set of meanings attached to a specific artefact" (Pinch and Bijker, 1986:30).

Thus, Geels' observation about the need to include the key actors was supported and extended earlier in the 1980s by Pinch and Bijker (1986), who draw attention not just to who they (the actors) are, but how they are involved. Accordingly, it means that once the different relevant social groups are identified, it is equally important to provide a detailed description of each of them, in order to highlight dimensions such as power or economic strength. This process of translation is described in Geels different case studies (Geels, 2007; Geels and Raven, 2007; Geels and Schot, 2008).

The third contribution of Geels is related to the rules through which actors' activities are coordinated, by considering that rules and institutions are the same in terms of their functions (Geels, 2004, 2006). With respect to their function of coordination and structuring of activities, Geels distinguishes three dimensions of rules. First, the regulative dimension which 'refers to explicit, formal rules' (Geels, 2004, 2007) includes, for example, government regulations. Second, there is the normative aspect of rules which includes "values, norms, role expectations, duties, rights, responsibilities" (Ibid). What distinguishes these rules from the former set is that they are internalised through actors' socialisation process. The third dimension comprises cognitive rules. The reality by itself does not have any meaning. It is the social context which provides the meaning to that reality by producing shared symbols associated with it. It is through these systems of rules that actors' activities are coordinated. For Geels, these rules constitute "the 'deep-structure' or grammar (in the Chomskyan sense) of ST- Systems" (Geels, 2004:905).

> As members of social groups, social actors share a set of rules or regimes, which guide their actions. These rules are the outcome of earlier (inter)actions. Social actors knowledgeably and actively use, interpret and implement rules systems. They also creatively reform and transform them. (Geels, 2004:907).

These processes lead to the maintenance or transformation of part or the whole of ST-Systems which catch on. Another contribution therefore concerns the dynamic interaction between systems, actors and rules. Indeed, “As members of social groups, actors share a set of rules or regime, which guides their actions” (Geels, 2004:907).

There is flexibility in how people think of or interpret the artefact but there is also flexibility in how the artefact is designed. This observation is supported by Pinch and Bijker (1986), who stress that there are several ways of interpreting the same artefact. For them, “different social groups have radically different interpretations of one technological artefact” (Pinch and Bijker, 1986:41).

Moreover, Geels (2004; 2006; 2007) addresses the issue of power relationships. In this regard he shows that actors such as firms, public authorities, users, scientists, and suppliers use regimes and rules for their own interests. A description of the relevant social groups in more detail is necessary to aid understanding of this power relationship. In the words of Pinch and Bijker (1986:34), “this is also where aspects such as power or economic strength enter the description, when relevant”. It appears that the relevant social group can be homogenous with respect to the meaning given to the artefact, but the actors’ intentions inside the same group are different. A detailed description of the relevant social group is important in order to perceive these dimensions because the relevant social group is not completely homogenous. The different actors involved in (inter)action do not have equal power. The resources and opportunities they have to realise their purposes are unequal in terms of money, knowledge, and techniques. Therefore, as with institutions, there is a need to specifically inquire into the organisational dynamics of ST-Systems. There are, what Geels terms, 'ongoing games' (Geels 2004).

The explanation provided by the ST-Systems is related to alignments and linkages between different processes including human actors and 'intermediaries' (Callon, 1986). Within levels this explanation follows a socio-technical logic, which investigates the interactions between heterogeneous elements or 'intermediaries' and actors. "The focus is on co-evolutionary interactions between ongoing trajectories: developments in one trajectory (e.g. regulations) may hinder or stimulate developments in another trajectory (e.g. technology or markets)" (Grin, et al., 2010:96). Between levels, the explanation is evolutionary, in the sense that the diffusion of niche-innovations depends on ongoing dynamics in the broader societal environment (regime and landscape) (Geels, 2004; 2007).

2.6. Criticism and discussion of the ST-Systems

The ST-Systems known as a Socio-Technical System framework has been criticized in recent articles for its heuristic and descriptive nature and a presumed lack of attention to politics and agency (Smith, 2005; Genus and Coles, 2008). The Socio-Technical

System framework conceptualisation of transitions has been constructively criticised on three general points.

The first concerns empirical and analytical levels which were raised by (Berkhout et al. 2004), who argue that "it is unclear how these conceptual levels should be applied empirically". By this "we mean that a socio-technical regime could be defined at one of several empirical levels" (Berkhout et al. 2004: 54). However, in the electricity domain one could study a regime at the level of primary fuel (coal, oil, gas) or at the level of the entire system (production, distribution and consumption of electricity). What looks like a regime shift at one level may be viewed merely as an incremental change in inputs for a wider regime at another level. From this point of view, such a framework remains suitable for the understanding of Bt cotton in this case study investigation.

The second criticism is the relative neglect of agency, especially in representations. Smith et al., for instance, argue that the Socio-Technical System is:

> overly functionalistic. Despite the breadth of the regime concept, there is a tendency to treat regime transformation as a monolithic process, dominated by rational action and neglecting important differences in context. […] existing approaches tend to be too descriptive and structural, leaving room for greater analysis of agency (Smith et al., 2005: 1492).

The third criticism is that the Socio-Technical System approach places too much emphasis on technological niches as the principal aspect for regime change. For instance, Berkhout et al. claim that MLP-approaches are:

> unilinear in that they tend unduly to emphasize processes of regime change which begin within niches and work upwards at the expense of those which directly address the various dimensions of the socio technical regime or those which operate ‘downwards’ from general features of the socio technical landscape (Berkhout et al, 2004:62).

However, despite all of the above criticisms, one can still agree with Geels (2006) and Schot and Geels (2008) who gave credit to the framework in relation to its simplistic design, that is to say, the ST-Systems is too simplistic and does not acknowledge the specificity of the transitions as a research topic. Grin et al. (2010) acknowledge that they could easily turn the criticism around to address this well-rehearsed micro-macro dilemma. They characterized their work on the MLP and transition pathways as a global theory that addresses the overall course of long-term change processes, but also acknowledged that this needs to be complemented by local theories which help to analyse how actors navigate, struggle and negotiate on specific alternatives. Van Driel and Schot (2005), Raven and Geels (2005) and Geels (2005, 2006, 2011) all agreed that the critics of the MLP are right in pointing at the heuristic value of the approach. As attested by Grin et al., (2010),

> we take this as a compliment, since we have pushed for a process theory in which theories are used as tools for the development of narrative explanations as explained above. Research of complex phenomena such as transitions cannot be reduced to the straitjacket of a variance theory, and will always contain elements of creative interpretation by the analysts (Grin, et al. 2010: 101).

Such a reply fully applies to this present research, which found in the ST-System an integrative framework which not only looks at the landscape, the niche and the regime, but also includes the translation and the way the NIS policy tool is constructed.

In order to understand individual trajectories one first needs to investigate the context within which, actors' a) draw on structural contexts, b) interact with each other, c) aggregate and select outcomes, and d) institutionalize outcomes in new structures (reproduction or change) (Grin, et al., 2010). One also needs to show that these trajectories are socially embedded games, where actors make moves, change tangible elements, and reproduce or change the rules of the game (Geels, 2007). The explanation then comes both from the rules of the game and the moves actors make (Grin et al., 2010).

The second explanation is evolutionary in the sense that pass processes impact on current and future processes. The Socio-Technical System framework provides detailed process explanations by analysing how actors draw upon structures in which they are embedded. Motivations, perceptions, aims, and interests of specific actors play a role here. While such detailed explanations may be useful for the analysis of local projects and niches, they are less practical for entire transitions which Pinch and Bijker (1984, 1986) and Callon (1986) have explored. With regard to the present study, there are three observations to make.

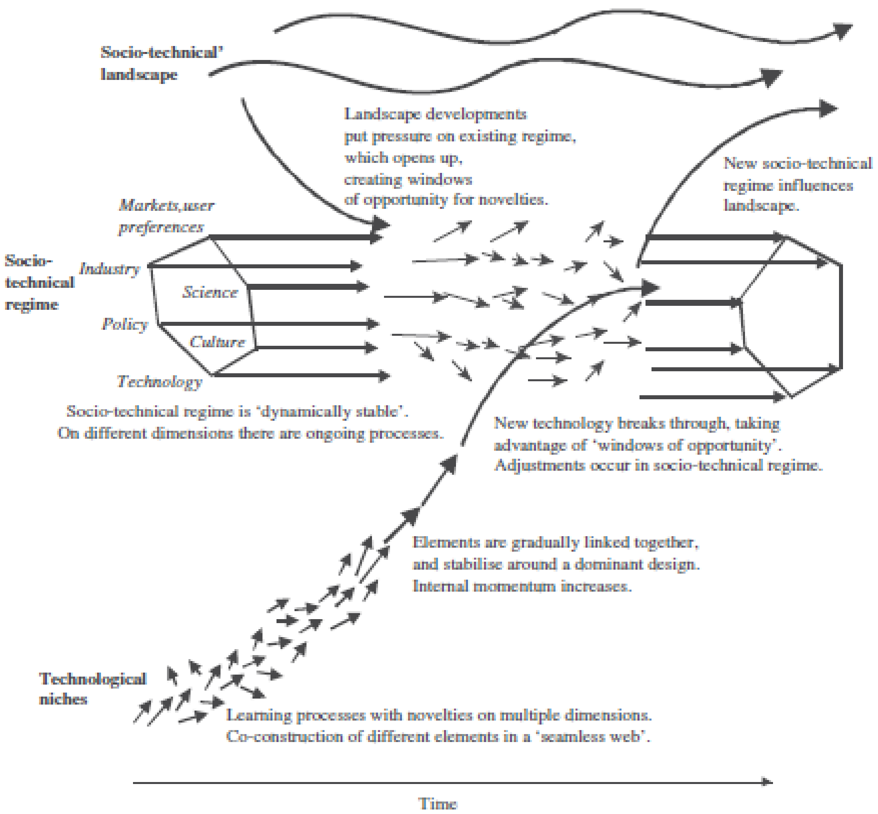
First, with the concept of landscape I can investigate the macro-level processes involved in the shift to the NIS policy tool for innovation diffusion in the Burkina Faso development policy regime. Such a landscape is described through the different development models shifts described in the introduction. In this connexion, the knowledge-centred development model, which is adopted by the Burkina Faso' government in the early 2000s, can be referred to as a "Socio-Technical Landscape". Its establishment at global and national levels as a development model will have some implications on the transformation of Burkina Faso's own development policy regimes. These implications are measured as pressures from the landscape on the development policy regimes, referred to as "Socio-Technical regimes" at the meso level.

Second, the concept regime developed by Geels is important here as through the concept of "Socio-Technical regimes" it interplays with the Socio-Technical Landscape, to illuminate the extent to which innovation at niche level can succeed or not at this meso level. Socio-Technical regimes "include scientists, users, policy makers and societal groups besides engineers and firms. These social groups interact and form networks with mutual dependencies, resulting in the alignment of activities. This inter-group coordination, is represented with the concept socio-technical regimes" (Geels and Kemp, 2007:443). A socio-technical regime is "stable in many ways (e.g. institutionally, organisationally, economically, culturally)" (Geels, 2004:913), thus making it difficult to replace. The concept of regime and its interplay with the landscape helps investigate crises in socio-technical regimes as a result of pressure from the socio-technical landscape, because the instability of such regimes create 'windows of opportunities' in the socio-technical regimes and has some implications for the adoption of the NIS policy tool as a new approach to innovation diffusion (Geels, 2004). In other words, this section analyses the windows of opportunity for new innovation approaches created following the emergence of the knowledge-centred development policy regime in Burkina Faso in early 2000s. In this strategy, as Geels highlighted, "Niche-actors hope that the promising novelties are eventually used in the regime or even replace it" (Geels, 2004:913).

Third the concept of niche is useful in studying the adoption of the NIS policy tool at strategic policy and operational level through Bt cotton case. Niches are characterised by Geels as the spaces where innovations are developed. The concept of niche will help identify the 'protected spaces' where the NIS emerged. The Forum of Scientific Research and Technological Innovation (FRSIT), where the NIS policy tool has been transferred and tested, is such an innovation niche, because, in this context like all innovations at niche level, the NIS policy tool is similar to those "experimental projects involving heterogeneous actors (e.g. users, producers, public authorities)" (Geels, 2004:912). The importance of the niche for the NIS adoption is because it describes the place where the learning and stabilisation processes of the NIS development and its specification took place. This process of diffusion has its own dynamic and needs to be understood in order to appreciate the transition between innovation approaches.

The interplay of landscape, socio-technical regimes, and niches provides therefore a coherent conceptual framework to investigate the adoption of the NIS framework as a development policy tool in Burkina Faso, and to appreciate how it is shaped through this process. This interplay of the landscape, regime and niche levels of analysis of the framework can be seen in the following figure.

Figure 2: A dynamic multi-level perspective on system innovations



Source: Geels and Kemp (2007:444)

2.7. Conclusion

The aim of this chapter was to demonstrate that the complexity of the processes involved in the NIS policy tool translation, the multiplicity of actors, the interlocking sets of rules, the dynamic interactions between all of these elements and the issue of power relations between actors calls for a systems analysis in general, and in particular a multi-level perspective of the kind that Geels offers, which also integrates the contributions of Pinch and Bijker (1984; 1986) Callon (1986) and Malerba (2004, 2005). For these reasons, this analysis of the NIS is treated as a Socio-Technical System. What is now needed is to find the best way for operationalizing this theoretical framework of a ST-Systems through appropriate research design and methods.

Chapter 3: Research Design and Methods

3.1. Introduction

Having argued in the previous Chapter that the ST-Systems approach is the most suitable analytical framework for the present research, it is now time to make explicit the research design and methods to be used for defining the broader approach of the study and for the data collection and analysis in line with my research questions. In this Chapter, I present a justification for the methodological choices in relation to data collection and analysis. This is crucial because it will show why an ethnographic approach within the qualitative research approach has been chosen as a component part of the investigation of the NIS policy tool translation. Here, the study's characteristics, orientations and aims concern not only the 'how', but also and most importantly the 'why'; it is about the claim that the National Innovation Systems (NIS) framework adopted in 2000s to foster systemic innovation has facilitated socio-economic development in Burkina Faso, with particular reference to the cotton sector and the introduction of Bt cotton. More specifically, interview and documentary review will also be used as methods, with open-ended interview guides and reading grid respectively, for collecting data from participants and documents. Analytical strategies provided by STS will help analyse and interpret the data collected.

The chapter is organised into three main sections. I will begin by examining the research design, description and justification in addition to the motives for the case study selection. The next section describes the field work process, settings for interviews and strategies for the analysis. The section makes explicit the use of the data collected and how the research has been undertaken in practice. Finally, the chapter discusses the ethical implications and the limitations of the study.

3.2. Research Design

3.2.1. Case Selection

The overview of the 3rd edition of the *Handbook of Science and Technology Studies* notes that: "Science and Technology Studies is a flourishing interdisciplinary field that examines the creation, development, and consequences of science and technology in their cultural, historical, and social contexts" (Hackett and al. 2007). This definition highlights aspects of the discipline which are of relevance in the choice of the design of this thesis, specifically scientific research, technological innovation and their interrelationships with the cultural, historical and social contexts of their production, use, and consequences. The present research can be located within the realm of technological innovation. It is about investigating the extent to which it can, or it cannot, be claimed that the National Innovation Systems (NIS) framework adopted in 2006 to foster systemic innovation has facilitated socio-economic development in Burkina Faso, in the context of a general aim to reduce poverty, with particular reference to the cotton sector and the introduction of Bt cotton.

As we have observed, the NIS is the latest policy tool for innovation diffusion in Burkina Faso, following the failure of a number of promising innovation diffusion tools which did not manage to boost socio-economic development. I have observed that, since the 1960s, the results of every new innovation diffusion tools have proved disappointing and unsatisfactory. Poverty has persisted for the majority of the population in Burkina Faso despite these efforts. As such, Burkina Faso represents a potential case to study the most recent policy tool (NIS) which aims to foster systemic innovation in order to facilitate the country's socio-economic development.

3.2.2. Qualitative Research

Considering Silverman' hypothesis that "our research problem defines the most appropriate method" (Silverman, 2005:6), I decided to use a qualitative approach because such an approach is suitable for research concerned with processes of a kind of the current research where, in addition to documentary review, field work with interviews appeared to be necessary to gain a more comprehensive understanding. Indeed, the ST-Systems conceptual framework has enabled me to unpack the network of organisations, individuals and institutions involved in the adoption of the NIS and its implementation in the cotton sector in Burkina Faso. These complex interactions cannot be adequately studied through a quantitative approach, since quantitative analysis of variable relationships lacks the capacity to consider the actions and interactions of individuals. It focuses on the isolation and control of variables. For example, quantitative approaches are unable to provide compelling accounts of "the ways that people engage structural conditions" (Puddephatt and Sprus, 2007:267).

The wider range of options provided by using a qualitative approach enables researchers to demonstrate "how people actively enter into the causal process through individual and joint action" (Puddephatt and Sprus, 2007: 265). Qualitative research enables the generation of answers to questions which involve complex phenomena with the objective of investigating the phenomena from the point of view of the participants. Qualitative approaches offer an interpretative capacity to analyse social facts with a specific focus on in-depth details. In this research, I wanted to see the social phenomena under consideration through the eyes of those being studied (Bryman, 2008), and qualitative research helps achieve this. It allows one to investigate in depth and detail the complexities surrounding the extent to which the NIS, as policy tool, could achieve socio-economic development using biotechnology cotton as a case study.

Among the various qualitative approaches, ethnography offers quite particular advantages for the present thesis. Even though they underline the difficulty of finding a clear definition of the term, because of its complex history (it spread to other disciplines from anthropology), Hammersely and Atkinson (2007:2) have sought to overcome the problem by adopting a practical approach consisting in focusing "on what ethnographers actually do, on the sorts of data that they usually collect, and what kind of analysis they deploy to handle those data" (Hammersely and Atkinson, 2007:2). It follows that for them

> ethnography usually involves the researcher participating, overtly or covertly, in people's daily lives for an extended period of time, watching what happens, listening to what is said, and/or asking questions through informal and formal interviews, collecting documents and artefacts –in fact, gathering whatever data are available to throw light on the issues that are the emerging focus of inquiry (Hammersley and Atkinson 2007:3).

3.2.3. Why an Ethnographic Approach?

The move from ethnography in general to ethnography as applied to science and technology requires some caution. Indeed, the laboratory which is the field in which ethnography was first applied in STS shares some characteristics with the face-to-face communities of anthropologists. Even though one might also point out that the lab nowadays can be very different to the following definition, Latour and Woolgar have pointed out, “The laboratory chosen, with walls all around, well deep-rooted in its paradigm, gathering inside all the necessary disciplines, held by an authoritative director resembles a classical field. In it, the geographical location and the function to be studied coincide…” (Latour and Woolgar 1996:30). However, it should not be lost sight of that science and technology have long been outside of ethnologists’ preferred field of interest. This classical interest is best read in the following long quotation borrowed from Latour and Woolgar (1996:30), the first to have brought ethnography into the field of science studies:

> It was the first time that hundreds of ethnologists have visited all the imaginable tribes, they have penetrated deep forest, enumerated exotic customs. They took pictures and documented family relationships and complex beliefs. In contrast, our industry, our techniques, our science, our administration have not been well studied. In fact, ethnologists only felt capable of studying traditional society’s traditions, witchcraft, symbolic representations, countryside, the marginalized […]. It is with fear and fright that they move forwards in our cities [...] they study the sociability of the people, but they don’t analyse the urban and the engineers’ everyday life […] they have more courage when it is about medicine, this is their well-known science. Even in this case, they like to study ethno-medicine […] (Latour and Woolgar, 1996:30).

A good deal of research in the laboratory has been carried out since, and ethnography established itself in the area. The approach is now used in other areas of science and technology studies, such as science policy. Nonetheless, as Latour and Woolgar acknowledged “it would be dangerous not to measure the limitations”. This thesis offers a case in point. The NIS policy tool translation in Burkina Faso, at both policy and operational levels, involved a wide range of actors who belong to different workplaces and geographical settings dispersed throughout the country, while some are outside of the country. For example, there are researchers, policy makers, cotton industries, cotton farmers, other users of research results, inventors/innovators, and multi-national actors. So many actors cannot be simultaneously in one specific space for a long enough period. The challenges that science and technology studies raise for ethnography is well underlined by Latour and Woolgar, as follows:

> The big difference between classical ethnography and that of science comes from the fact that the field of the first one is similar to territory, and that of the second one takes the shape of a network. The Alladians studied by Auge live between the lagoon and the ocean except for some incursion on the land and the big city of Abidjan. But the stimuli in the brain of our laboratory are in Sweden in a pharmaceutical firm, in London […], in Dallas […], in Paris, New York, and also in Jolla. […] this shows that the ethnographer must travel more. The nodes of this network are often laboratories, but also offices, firms, hospitals, business centres, private residences […] (Latour and Woolgar 1996:29).

This distinctiveness of the field of STS and the challenges it raises in relation to classical ethnography is important for the purpose of this thesis because it has significant implications regarding the data collection strategy. In addition to this aspect related to the setting, this case study on the NIS policy tool translation involves some events which have already happened, and so cannot be observed directly. Finally, even where this process regarding the NIS is current, organisations may not disclose some information about themselves, resulting in the refusal of external actors to take part in some meetings or even to be informed about some processes related to the subject of the study. Regarding this temporal aspect, it is in what Commaroff has termed, its “*neo*-modern” sense that the ethnographic approach is relevant to this thesis. For Commaroff the idea of “neo-modern” ethnography, "seeks to construct imaginative sociologies of terrains both near and far, more or less complex, familiar and strange, local and global” (Comaroff 1992: ix). Contrary to its classical conception, which tended to restrict it to the present, the neo-modern ethnography supports the idea that ethnography cannot aim “to penetrate beyond the surface planes of everyday life, to plumb its invisible forms, unless it is informed by the historical imagination” (Comaroff 1992: xi).

In summary, ethnography is considered in this thesis as it is used in science studies as well as in its “neo-modern” sense. This has implications for the data collection strategy.

3.3. Methods

Given the aim of this research is to investigate the two projects, the NIS inspired policy framework and the Bt cotton innovation system, in facilitating development in Burkina Faso at both strategic policy and operational levels, it was considered that both documentary and interviews data were necessary. However, before reviewing the documents (grey literature and literature review) and before going to the field to conduct the interviews with relevant participants, there is a need to select the sample of documents and to identify the kind of participants to be interviewed. As defined, the “document [or participants] selection is a decision process in which the user evaluates a retrieved document [individuals] based on its [their] surrogate […] the most important question is what are the processes and factors involved in arriving at a decision?” (Wang and Soergel, 1998:115-116).

3.3.1. Data and Sources

Such an investigation requires a process to select the documents and the interviewees. Thus, I decided to review systematically all the available documents in relation to the aim of this research. As a result, after the identification of the main themes related to the topic with regard to the historical context of innovation and development in Burkina Faso, the transition between the farming system innovation diffusion tool to the NIS diffusion tool and the transition from a conventional cotton to a Bt cotton ST-System in Burkina Faso, related sub-themes in line with the main themes were identified. Among them were the political, social and economic histories of Burkina Faso, the tools used for innovation, the history of key institutions such as the IDRC (International Development Research Centre), UNI-MERIT and FRSIT (National Forum for Scientific and Technological Innovations), and the history of biotechnology and development in Burkina Faso spanning cotton regimes before 1900 to the late 1900s.

The sources of data in relation to these themes were identified. First the university of Nottingham library online search through the web of knowledge and available books in the university catalogue was the potential source of data. In addition, some relevant institutional websites (IDRC, UNI-MERIT[17], CNRST: the national research centre, INERA: the agricultural research centre, FRSIT, cotton industries: SOFITEX,

[17] United Nations University - Maastricht Economic and social Research and training centre on Innovation and Technology

SOCOMA and Faso Coton) were investigated, and key reports, presentations, workshops and conference papers were identified. Finally given that my study is conducted within Burkina Faso, relevant institutions such as ministries and other institutions' reports and policy documents were accessed during fieldwork directly in hard copies. This included newspapers. As specified in the tables below, the specific documents from the grey literature were identified and used as potential sources of data in addition to the interview data which covers the everyday processes in the adoption of the NIS as a policy tool and on the Bt cotton innovation system. The interview guide is in the annex of this thesis. The following table makes explicit the method, the kind of the data needed and their sources.

Table 4: Historical context of Innovation and Development in Burkina Faso

Data	**Data sources**	**Methods**

— Political history of BF
— Social history of BF
— Economic history of BF
— Tools used for innovation
  ○ Content
  ○ Objectives of the innovation
  ○ Assumptions/theories
  ○ Results
	Published books
	published papers
	world bank reports
	CNRST reports
	MESS reports
	MRSI reports
	Science Policy documents
		Documentary review

Source: Processed by author

Table 5: Translation of the NIS Policy tool in Burkina Faso

Data	Data sources	Methods
— History of the IDRC ○ History of its programme on science, technology and innovation policy ○ Key actors which led institution ○ IDRC'S Regions of Intervention ○ Interpretation of Innovation Systems — History of the institution UNI-MERIT ○ History of its programme on science, technology and innovation policy ○ Key actors which led institution ○ UNI-MERIT'S Regions of Intervention ○ Interpretation of Innovation Systems — History of the institution FRSIT ○ History of its programme on science, technology and innovation policy ○ Key actors which led institution ○ FRSIT'S Regions of Intervention	Project description Workshop reports Research reports Training reports Institutional newspapers, Mission reports Technical reports Conference papers review reports FRSIT different editions reports Organisations' website Internet	Documentary review

<table>
<tr><td><li style="list-style-type:circle">Interpretation of Innovation Systems</td><td></td><td></td></tr>
<tr><td>FRSIT-CRDI’s Project
Project development
Justification of project
Composition of project team
Organisation set up for project implementation in
Trainings based in BF
Content
Objectives
Trainers
Trainees
Training justification
Trainings which took place outside the country
Place/country of training
Institutions of training
Mode of knowledge of the institutions
Reason for choice of training institutions
Content of training
Objectives of training
Trainers</td><td>Project description
Workshop reports
Research reports
Training reports
Institutional newspapers,
Mission reports
Technical reports
Conference papers
review reports
FRSIT different editions reports
Organisations’ website
Internet
interviews</td><td>Interview
Documentary review</td></tr>
</table>

- Trainees - Training justification - The initiators of training • Project implementation - Activities undertaken - Justification of implemented activities - Objectives of these activities - Involved actors - Justification of actors' selection • Project evolution to date - Project duration - Project's institutional affiliation - Lessons learnt from project - Appreciation of project's achievement - Project's contribution to policy formulation - Justification of achievement • Interaction between key actors in BF with UNIT-MERIT and CRDI's actors • Existence of other innovation approaches in BF - Content of the approaches, - Similarities and difference with		

regard to the NIS		

Source: Processed by author

Table 6: Transformation of cotton regime in Burkina Faso from traditional to Bt cotton ST-Systems

Data	Data sources	Methods
— Cotton regimes before 1900 to 2000 o Work organisation o Variety of cotton grown o Tools and tools makers o Cotton usages — Bt cotton regime 2000 to 2012 o Problems o Efficacy of old methods in relation to the problem o Occasion of meeting of Monsanto o Interposition of local actors in the solution o Mobilisation of local actors o Identification of actors o Actors' consent o Interest in the other actors in the network	Published books Published papers INERA reports CNRST reports Presentation reports Research reports Institutional newspaper, Technical report review report Burkina Biotech Association different editions reports Local news and news papers Organisations' website Interviews	Documentary review Interview

○ Actors' expectations ○ Technological transfer strategy • Activities undertaken • Justification of activities • Objectives of activities • Concerned actors' role • Concerned actors' role • Justification ○ Position of actors in the network		

Sources: Processed by author

Table 7: Bt cotton Innovation System: actors, institution and benefits

Data	Data sources	Methods
— Actors • Producers of knowledge in cotton biotechnology ○ Identification ○ Equipment ○ Organisation ○ Specialisation ○ location • Users of knowledge in cotton biotechnology ○ Identification	Published books Published papers INERA reports CNRST reports Workshop reports Presentation reports Research reports Institutional newspaper, Technical report review report	Interview Documentary review

○ Equipment ○ Organisation ○ Expertise/knowledge ○ Location — Linkages and their mechanisms • Mechanisms • Objectives • Set up date • Initiators • Reasons/circumstances • Mode of coordination • Previous mechanisms • Reasons for changes in the mechanisms • Involved actors in the implementation of current mechanisms • Difficulties • Mode of resolution • Support from another actor in the network • Actor' reaction — At policy makers level	BBA different editions reports Local news and news papers Internet Interviews	

• Existence of innovation policy ○ State of research ○ State of higher education ○ Existence of sectoral innovation policy ○ Agricultural higher education — System performance in terms of networking		

Source: Processed by author

3.3.2. Data Collection

After the identification of the themes and sub-themes, and having defined the methods (interview or documentary review), it was important to specify how each of them is used practically in this research. Indeed, as already stated above in the design section, my research is qualitative research, which included an ethnographic approach. The aim of this section is to identify the appropriate method for data collection and analysis consistent with this approach (Hammersley and Atkinson, 2007).

This thesis will rely primarily on interviews and documentary review, and will draw on participatory observations made at key conferences and meetings attended by the researcher.

- **Documentary review**

Before getting into the field to conduct my interviews, I needed to "set the scene" with regard to the problem in hand and the fieldwork to be conducted, so preliminary data were collected in order to increase my understanding of the subject and enable me to design a guide for the interviews. As stated by Hammersley and Atkinson (2007), "documents can provide information about the settings being studied, or about their wider contexts, and particularly about key figures or organisations" (Hammersley and Atkinson, 2007:122). These sources include primary as well as secondary or grey data. I accessed some material from the Internet, to supplement articles on the NIS policy tool translation. In the course of the interviews, interviewees themselves provided me with further documents to clarify aspects they discussed or they thought could be relevant to the matters under discussion. These particular documentary data sources collected in the event of the field work would corroborate, or contradict, some of the data collected through interviews, given that because of impact of time and interest, research participants can report selectively in interviews. As a result of that, as noted by Hammersley and Atkinson (2007), "documents may play a key role in facilitating comparative analysis; both generating a sense of how the case (s) investigated are similar to and different from others" (Hammersley and Atkinson, 2007: 123). Additionally, as in the case of the present research, documentary review stimulated the analysis of the data by giving more details on some key ideas. This possibility has also been raised by Hammersley and Atkinson (2007), "Equally important, documents may be of value in stimulating analytic ideas. The development of generic concepts demands a broad and eclectic reading of textual sources […] on differing substantive topics" (Hammersley and Atkinson, 2007: 122).

- **Interview**

The NIS as a policy tool, which is the object of this study, is a socio-technical system (ST-System) involving actors (users of knowledge, producers of knowledge, policy-makers and regulators) whose relationships are coordinated by institutions. As such, the processes involved in the NIS as a policy tool translation resemble those of any organisational system. In this regard, the interview is one of the key methods for the collection of information about these processes. As Beaud and Weber remark, “if the researcher cannot observe *in situ*, he asks the research participants to report to him their own observations” (Beaud and Weber, 1998:176). In addition, the interview enables the researcher “to obtain the intricate details about phenomena such as feelings, thought processes, and emotions that are difficult to extract or learn about through more conventional research methods [such as questionnaire]” (Strauss and Corbin, 1998:11). An in-depth semi-structured interview guide was used as a tool to conduct the interviews. The open-ended interview guide is particularly relevant because of its flexibility (Silverman, 2005). In total 60 interviews have been conducted. A breakdown of the interviewees who participated in the face to face meetings and their institutional affiliations are as follows: 12 researchers, 6 policy makers; 2 Monsanto representative; 3 cotton industry representatives; 15 small farmers; 7 large farmers, 9 civil society/NGO representatives, 1 NEPAD representative,1 ANB director, 3 IDRC staffs, 1 UEMOA representative. There was no pre-determined number of interviews to be conducted. The number of research participants is determined by the principle of saturation. For Strauss and Corbin “This term denotes that during analysis, no new properties and dimensions emerge from the data, and the analysis has accounted for much of the possible variability.” (Strauss and Corbin, 1998:158).

Concerning interviews with farmers, I decided that two regions of the country would be considered because of the contrast they present. These regions are the west of the country with large-scale farmers and the central part with small-scale farmers. The western part of Burkina Faso is the economic centre, and the rainy season is longer and heavier than in other parts of the country. Before meeting the farmers, I was granted permission to do so by the relevant cotton industry in charge of the region. Lastly, I was granted permission by SOFITEX, the main cotton industry, to conduct interviews with representatives of the three industries.

With regard to language, many local languages co-exist with French, the country's official language. It was decided that French and Moore (my own mother tongue) would both be used for the interviews. This would allow me to conduct the interviews personally and analyse the data without the need for a third person for translation. All the different actors interviewed spoke either French or Moore. I was personally hosted by the New Partnership for Africa's Development (NEPAD)'s Africa Bio-safety Network of Expertise (ABNE). This institution is based in Burkina Faso because, the country was among the first to have to have adopted biotechnology cotton. This was negotiated prior to my arrival in Burkina Faso. Thus, during my fieldwork I benefited from their facilities (office space and transportation to some villages for interviews). I also used my motorbike, which is the most common means of transport in the country, to travel to meet interviewees (mostly researchers and policy makers) in the capital city of Ouagadougou.

- **Direct observation**

Prior to my fieldwork, I was informed through the local news of a workshop on biotechnology which was taking place during my fieldwork time plan. Given that my study has two dimensions to investigate the NIS inspired policy framework and the Bt cotton innovation system, in facilitating development in Burkina Faso at both 1) strategic policy and 2) operational levels, I scheduled the fieldwork for three months (the beginning of March till the end of May) to coincide with the workshop. This three-week workshop involved a wide range of biotechnology actors in Burkina Faso, but was closed to the public. I ensured that I was in the country for the period in question. This strategy was informed by the expectation that this workshop, organised by the President's advisors to discuss the impact of biotechnology on the country's economic development would provide a platform for networking and, above all, an opportunity to meet the different actors involved in the implementation at operational level of the NIS policy tool especially Bt cotton, if I could gain permission to attend. At such an important meeting, there was also the possibility of getting referrals to other valuable contacts.

My participation in the workshop was negotiated with the help of the general secretary to the president of the Economic and Social Council (CES). I was granted permission, after a long process of negotiation, even though, with the exception of the opening and closing ceremonies, the workshop was not technically open to the public. As a student, I went through the legal procedures required to gain access and was accepted as an observer but not allowed to ask questions during the workshop. This restriction was a fair price to pay for the opportunity to engage in observation and networking.

My expectations about the value of attendance were fully met. The number of actors eventually interviewed was significantly greater than initially expected, and I was able to derive significant ethnographic insights by being a part of the entire process.

Some interviewees, whom I had contacted initially by email before coming for my fieldwork, were to be present at this workshop. Other people who were not initially part of my interviewees' list were also present. I organised individual meetings with most of them and sometimes was able to talk with individual participants during breaks. My observations through attendance and participation in this workshop gave me a clear map of the different actors involved in the implementation of the NIS through Bt cotton technology, and a sense of the network and power relations which was not accessible through documentary review or from individual interviews, highlighting the significance of chance in successful fieldwork, besides the formal strategies. Beaud and Weber, added that fieldwork "depends essentially on "circumstances" "occasions" which happen on the field" (Beaud and Weber, 1998:127).

Although I was not able to ask questions in the conference room, the circumstances of the workshop provided a framework for speakers that constrained them to provide at least a minimum amount of information. At the end of the three weeks' workshop, the combination of individual presentations gave a relatively full picture of the network of actors around biotechnology cotton innovation. Also, policy makers were not restricted in their discussion and could ask any questions in the workshop which was useful in promoting fuller information.

Being able to talk with participants during breaks and record these discussions deepened my understanding of the issues. More importantly I was able to make direct contact with policy-makers, civil society actors, researchers, industry representatives, bio-safety officers, the Monsanto representative in Burkina Faso, government advisors, and ministers. It was extremely beneficial as this workshop gave me a fuller picture of who was doing what, with whom.

3.3.3. Field Work Process

Hammersley and Atkinson observed that regarding the research process:

> [T]he case we might wish to select may not be open to study, for one reason or another; and if they are, effective strategies for gaining access to the necessary data will need to be developed. Similarly, not all the people we wish to observe or talk to, nor all the contexts we wish to sample may be accessible […]. The problem of gaining access to data is particularly serious in ethnography, since one is operating in settings where the researcher generally has little power, and the people have pressing concerns of their own which often give them little reason to cooperate. (Hammersley and Atkinson, 2007:39-40).

This section tells the story of how the present research has been prepared and conducted in the light of the second of the potential difficulties Hammersley and Atkinson (2007) point out in the previous quotation - in relation to individuals who may not have reason to want to cooperate. The first challenge was to identify my research participants. For this, my literature review in the course of defining my research topic, has been useful. During my first year, I reviewed Burkina Faso's development policies, including the agriculture sector innovation diffusion strategies.

For this I used a number of reports (conference, workshops and policy reports) thanks to which I was able to track down key people such as researchers, policy-makers, users of research results, inventors, innovators, national and international actors involved in the NIS policy tool adoption and implementation processes. The phone numbers and email addresses of these potential research participants were all available in the reports. I sent emails to more than 50 people only, 10 of whom responded to this initial contact. When I reached Burkina Faso, I contacted those who did not reply by phone or met them at their work places. Almost all of them were willing to meet for an interview following agreement on the time and location.

To access the participants, six ‘gatekeepers’ were used to get access to participants sometimes at different levels. Indeed, before my arrival in Burkina Faso, I had exchanged emails with two leading technical agents with whose help I was able to get in touch with four more gate keepers and some large cotton farmers whose details were not available on the reports. As for small farmers, most of the time they do not take part in the meetings, workshops and conferences. They are usually represented by their national union. One of the technical agents from the National Union of Cotton Farmers (UNPC-B), who is one of the six gatekeepers, helped me to get in touch with the union president and all his colleagues who are large scale farmers. He also led me toward his colleagues. I always agreed a timeline with this technical agent who was based at the UNPC-B office in Ouagadougou. All the six so called “gate keepers” facilitated my first contact with the cotton industries, cotton farmers and officers.

These technical agents were indeed key people in the process of meeting with cotton farmers and cotton industries. The large-scale farmers on the committee (UNPC-B) and some of the small farmers were already aware of my research and willing to have face-to-face discussions without knowing me in person thanks to these gate keepers. The officer at UNPC-B facilitated my meeting with the president of Faso cotton industry and another meeting with the technical agent in charge of the small cotton farmers in the central region. In addition, some interviewees also pointed me in the direction of colleagues whom they thought could give more details about some aspects on the NIS translation. This strategy of relying on some of the participants to get more participants is in line with standard practice in ethnographic research, as Beaud and Weber pointed out:

> [T] he fieldwork is therefore built with the interviewees help, or more exactly with the help of some of the interviewees. They are those who will overcome the main obstacle, those who will make you penetrate in the field, […] They will help you, open doors which, without them, would have always been locked, enter in contact with people that you would have not been to see otherwise. (Beaud and Weber, 1998:126)

However, one must be cautious as to the “good faith [of an interviewee] in facilitating the research” (Hammersley and Atkinson, 2007:104) because, “it may be designed to control the findings” (Hammersley and Atkinson, 2007:104). In this study precautions were taken in this respect because most of my interviewees were contacted directly by me instead of through third party, even though the name and contact was given by a third person.

The policy-makers, researchers and civil society actors were mainly contacted by email and times for meetings at their workplaces scheduled and agreed by both parties. The interviews with the minister of the newly created ministry (the Ministry of Scientific Research and Technological Innovation) provided me with the context for the translation of the NIS policy tool. The key actors in this translation process were from the FRSIT and ANVAR who were active in the process of adopting such a new policy tool. Consultants who trained the policy-makers and researchers on the fundamentals of the NIS framework in the translation process were also interviewed.

As a self-funded student, I had a limited budget, and my field work and most of the transcription were done entirely by myself, with the help of two colleagues

3.4. Data Analysis

The data collected were subject to thematic analysis. Before such analysis, the collected data from documents were organised and the data from interviews were transcribed into written materials.

3.4.1. Production of Written Materials

- Organisation of reading notes

The notes from the documentary review were first manually summarised and then electronically saved. Particular effort was made to gather details about the context of the production of every piece of document in order to be able to characterise their content and through crossed-checking to highlight what each document includes and what it omits.

- Transcription of interviews

All interviews were transcribed word for word. This consisted for each recorded interview in listening and writing down systematically the oral statement. Systematic transcription is recognised as necessary to capture the detailed contextual elements of the interview. As Beaud and Weber underlined, “interviews are richer and interpretable if the transcriptions are precise [...]: consider silences, underline hesitations and procrastination, note the inflexions of the voice, indicate differences in tone, note gesture and mimics associated with the speech etc.” (Beaud and Weber, 1998:243-244). In total, the transcribed interviews made up more than 70,000 words. The transcribed interviews together with the reading notes were then subjected to thematic analysis.

3.4.2. Analysis of Written Materials (Transcribed Interviews and Reading Notes)

The analysis of themes emerged from both the interview and documentary review data drew on established analytical strategy in Science and Technology Studies.

In this research, I used qualitative approach for collecting the data; ethnographic interviews have been used to collect the data. Once I gathered the information, I faced the next challenging process. As acknowledged by Aronson, “researchers are faced with the decision on how to analyze the data. There are many ways to analyze informants' talk about their experiences […] thematic analysis is one such way.” (Aronson,1994:3). In the framework of this study, thematic analysis was then used to analyze the data. A clear definition is given here by Aronson, (1994:4), for him, “Thematic analysis focuses on identifiable themes and patterns of living and/or behavior”. The analysis of these materials or themes was systematic. I have chosen what is call the “bottom up” analytical process at both semantic as well as latent level. Indeed, in the context of the thematic analysis that is used here, some metaphors are used by interviewees to symbolize or characterize a specific phenomenon. In this process, as recommended by Braun and Clarke, (2006: 82) “[…] steps [or stages are necessary] in this process". Thus, after transcribing interview data, I proceeded in familiarising myself with the data collected and identifying the key dominant themes that emerge from the interview and documentary review. "A theme captures something important about the data in relation to the research question and represents some level of patterned response or meaning within the data set." (Braun and Clarke, 2006: 82). As a result, in the present research, the themes are identified by bringing together components or fragments of ideas or experiences, which often are meaningless when viewed alone. In other words, it is agreed that, stories are all pieced together to form a comprehensive picture of their collective experience.

The preliminary main themes are related to the historical context of Innovation and Development in Burkina Faso, the translation of the NIS policy tool in Burkina Faso, the Transformation of cotton regime in Burkina Faso from traditional to Bt cotton ST-Systems, and the Bt cotton Innovation System: actors, institution and benefits. From these major themes, some subthemes (description of the main themes) have emerged and been identified in relation to every theme. At this point of the study, I need to begin the reconstitution of the story line. As stated by Aronson, (1995:3), "Once the themes have been collected and the literature has been studied, the researcher is ready to formulate theme statements to develop a story line".

Consistent with this strategy, I reconstructed the network of the translation of the NIS policy tool both at policy and operational levels (with Bt cotton) in order to develop a story line. The frames used for this reconstruction are suggested by my problematic and provided by the conceptual framework (ST-Systems). That is, for each dimension of the ST-Systems concept, analysis consists in identifying from the body of interviews and reading notes, actors and processes associated with them. This is similar to what Strauss and Corbin call in 'Grounded Theory' perspective, 'open coding', that is:

> data are broken down into discrete parts, closely examined, and compared for similarity and differences. Events, happenings, objects, and actions/interactions that are found to be conceptually similar in nature or related in meaning are grouped under more abstract concepts termed "categories" (Strauss and Corbin, 1998:102).

To maintain confidentiality a randomly distributed number code is attributed to each interviewee. For instance, (interview#12) refers to interviewee number 12 that I met during the time spent on the field.

3.5. Ethics

The ethical guidelines provided by the University of Nottingham were followed. There are six key principles in the University of Nottingham ethical guidelines, which are as follows:

- Ensuring that the ethical basis and design of research projects are ethically sound and have received the approval of relevant ethics committee(s) and all relevant statutory regulatory authorities before they commence;

- Ensuring the safety of all involved in the research process by ensuring that the research is carried out in accordance with health and safety policies and legislative requirements;

- Ensuring that research is conducted in a suitable working environment with appropriate equipment and facilities;

- Ensuring the probity of the financial management of all research projects, and seeking to provide optimum value for the public or private funding agencies who have invested in them, including effective project management of agreed project plans and appropriate quality standards, as well as the timely delivery of any scheduled tangible outcomes;

- Management of research data in accordance with the Data Protection Act 1998 and any other legal provisions, conditions and guidelines that may apply to the handling of personal information;

- Undertaking professional development appropriate to the research.

Indeed, Bryman (2008) summarizes the areas for ethical consideration as: Harm to participants, lack of informed consent, invasion of privacy and deception. Following consideration of these ethical aspects, it can be concluded that ethical considerations are key in this study. Prior to the interview, the objective of this research was made explicit to the interviewees. They were also informed that the findings would be presented in an academic thesis and published in scientific journals or books. They were assured that all the information used in the document, such as quotes and comments, would be anonymous to protect their confidentiality (all these steps follow the University of Nottingham's research ethics framework). In addition, prior to interviews, interviewees were asked whether the interviews could be recorded. All the interviewees agreed and most of them gave a written statement. I gave interviewees all my contact details (telephone number, email, home and university addresses) and asked them to contact me with any queries they had regarding this research. Their quotes and comments were treated as anonymous in the thesis.

Over and above the practices carried out in line with the guidelines, and although the interviews for the research did not require approval by any formal ethics committee, the present research did present one complicating factor in relation to consent and ethics.

In the conduct of the research, two levels of consent were documented (oral and written). In Burkina Faso, there is a high likelihood of individuals who do not know how to read or write, and who do not agree easily to make a written statement – except for some special occasions such as wedding documents, family documents (birth certificates). These people may hold the view that a written statement can be used for other purposes and, given that they cannot read the content unless translated to them, they are very hesitant about signing a paper that might be used against them.

It is interesting to note that they are likely to place trust in the individual researcher rather than an institution which offers assurances in relation to the kind of consent form which is in standard use in the UK, for example. For this research, I did not insist that every person sign the consent form in the first instance. I devoted my time explaining them who I was, what I was doing and why I wanted to have an interview recorded with them. Most of the time they gave clear verbal assent, and were happy to talk to me. The agreement took the form of an acknowledgement, with a "yes of course I can talk to you if it is for that". For this research, this issue concerned mainly small farmers who agreed to make an oral statement, and this was recorded at the beginning of the interview.

3.6. Conclusion

In this chapter, I described the research design and method. I made clear that an ethnographic element enriched the available qualitative research methods for the study of the NIS policy tool translation in Burkina Faso. This approach was considered suitable because the methods used are most appropriate given the kinds of processes which are the focus of the thesis. These methods involved documentary analysis, participant observation, and elite and semi-structured interviews, consistent with the practices of STS research.

Findings derived from the analysis will be organised into two main parts: Part two is about the NIS policy tool in the context of a knowledge-centred development regime in Burkina Faso. This will include 1) the historical context of innovation for development in Burkina Faso and from this standpoint 2) the translation of the NIS as a policy tool in Burkina Faso. Part three is about the implementation of the NIS policy tool at operational level in the cotton sector with Bt cotton innovation. This part includes 1) the transformation of Cotton system in Burkina Faso from traditional to Bt cotton ST-Systems, 2) Bt cotton Innovation System: actors, institutions and benefits.

Part II

National Innovation Systems and the Knowledge-Centred Development Policy Regime in Burkina Faso

Chapter 4: Crisis of Socio-Technical Regimes and the Quest for a New Innovation Regime in Burkina Faso

4.1. Introduction

In the introduction to this thesis (Chapter 1), I traced the shifts in development policy in Burkina Faso since the 1950s (Section 1.4.2 of the chapter) in order to highlight the emergence of the knowledge-centred development policy from the early 2000s. The shift to this latter development policy is analysed in this thesis as a change in the overall socio-technical landscape. Applying the conceptual and methodological insights described in Chapters 2 and 3, the present Chapter investigates the 'windows of opportunity' (Geels, 2004) that have emerged at the level of the socio-technical regimes as a result of downward 'pressure' from the socio-technical landscape, and the implications for the adoption of the NIS policy tool. It explores the socio-technical environment within which different innovation diffusion approaches for development were established. In this regard, the Chapter aims to investigate the socio-technical regimes, that is, successive networks of interactions between the human and the technical (knowledge, tools and technics), by taking into consideration their different approaches to innovation diffusion and their implications for science policy. Prior to the NIS policy tool, approaches to the diffusion of innovation in Burkina Faso included the 'Integrated approach around a cash crop', the 'Training and Visits' approach, and the 'Farming System' approach which will be explained in detailed later in this chapter. For each of the innovation diffusion approaches adopted, the incumbent socio-technical regimes show specific structures, which will lead me in Chapter 5 to interrogate which socio-technical regimes inform the NIS policy tool.

In this Chapter, I begin by investigating the nature of Burkina Faso's social and political economy as this is key to characterising the specific role of the state in the process of adoption of the NIS policy tool. Then, keeping in line with the shifts in development policy at the landscape (or overall socio-technical setting as described in chapter 2) level (Chapter 1), I will examine the changes in corresponding innovation diffusion approaches and science policies, as well as the organisations put in place for their management. This will enable me to highlight in the conclusion why there is a need for the NIS as a policy tool for innovation diffusion in Burkina Faso.

4.2. The Social and Political Economy of Burkina Faso

One distinctive aspect of the NIS policy tool in comparison to other interactive[18] tools for innovation diffusion such as the Farming Systems and the Multi-Actor Platform as it will be described later in this Chapter and in Chapter 6, is the role it attributes to the State as compare to the other (Lundvall, 2007). It is therefore important to know the nature of the social and political economy of Burkina Faso because it will help to clarify the socio-political context of the NIS policy tool at the macro-level.

Burkina Faso is a landlocked Francophone country in West Africa. Its size is 274,200 square kilometres (105,900 sq mi) with a current estimated population of more than 18 million in 2015. Formerly called the Republic of Upper Volta, it was renamed on the 4th of August 1984 by President Thomas Sankara to mean "the land of upright people" in the combined national languages Mooré and Dioula, the major native languages of the country. Figuratively, 'Burkina' may be translated as 'men of integrity' from the

[18] Use here in contrast with the linear approach to innovation. In a systemic point of view it involves co-operation and networking between producers and users of the innovation

Mooré language, and "Faso" means "father's house" in Dioula. The inhabitants of Burkina Faso are known as *Burkinabè* (Sissao, 2003). Bounded by Benin, Togo, Ghana, Ivory Coast, Mali and Niger, all of these countries, with the exception of Ghana, were under French colonial rule between 1900 and 1960.

Burkina Faso is culturally diverse with more than 60 living languages spoken across the nation. With such a rich ethnic and traditional disposition, the country is proud of its cultural diversity (Ki-Zerbo, 1978; Nacanabo, 2003). Despite poverty and difficult living conditions, the people of Burkina Faso (the Burkinabé) are hospitable and tolerant of their cultural differences (Bourdet, 2004; Konate, 2003; Hazard, 2003).

4.2.1. From Colony to State

Colonial power is responsible for the establishment of the modern State in Burkina Faso. This colonial power also introduced changes in the way society was organised. A revision of the Organization of French Overseas Territories (OFOT) began with the passage of the "Loi Cadre" of 23rd of July 1956. This Reform Act was followed by re-organizational measures approved by the French parliament early in 1957 that ensured a large degree of self-government for individual territories. Burkina Faso which was known as Upper Volta became an autonomous republic on the 11th of December 1958 (Crowder, 1968; Sissao, 2003). On 5th of August 1960, it attained full independence from France and is now a member of the African Union (AU), Community of Sahel-

Saharan States (CEN-SAD), La Francophonie[19], and the economic Community of West African States (ECOWAS).

4.2.2. Governance

Since it gained independence in 1960, a number of political regimes have successively controlled the country. Between the 1960 and 1966 was the birth of the first republic presided over by Maurice Yameogo. Between 1966 and 1980, the Colonel Aboubacar Sangoule Lamizana took power through a military coup-d'état and led alternate military regimes: the second and a third republic. After this, four successive military regimes held power between 1980 and 1987. The first took place between 1980 to 1982 led by Colonel Saye Zerbo; the second was between 1982 and 1983 with Colonel Jean-Baptist Ouedraogo; the third took place between 1983 and 1987, the revolutionary period with Captain Thomas Sankara, and the fourth with Captain Blaise Compaore since 1987 till 1992 (Sissao, 2003). From 1992 Captain Blaise Compaore built up the fourth republic and led the country until 2014. In October 2014, a popular insurrection led to the short military regime of Colonel Yacouba Issaac Zida which lasted only 20 days and on 21st of November 2014, Michel Kafando was chosen to lead the country for a transitionary period during the organisation of a vote to choose a president in October 2015. Such transitory political regimes in Burkina Faso have obviously had a deep impact on the science and innovation policy for development evolution. In the next section I am going to make explicit the evolution of science, technology and development in Burkina Faso through the shift of the different innovation diffusion approaches.

[19] Is the cooperation measures which have been taken to promote the French language, cultural diversity, sustainable development, education and training. La Francophonie was created in 1970. Its mission is to embody the active solidarity between its 75 member states and governments (56 members and 19 observers) in order to promote French language and culture

4.3. The Crisis in the Socio-Technical Regimes

The implication of changes in one element of a socio-technical system for other elements has been well described by Geels (2004). This section will analyse the different innovation diffusion tools implemented in Burkina Faso until the end of the 1990s followed by the emergence of a new systemic tool, the NIS, in 2006. In other words, this section analyses the windows of opportunity for new innovation diffusion tools created following the emergence of the knowledge-centred development policy in Burkina Faso in early 2000s which necessitated a well-designed systemic tool to implement it.

4.3.1. Technological transfer: 'Integrated Approach Around Cash Crop20'

The period from 1900 to the 1970s is marked by what is known as technological transfer from developed to underdeveloped countries (Gaillard, 1999). The main tool to such technology transfer was the 'integrated approach around cash crop' (Nauleau, 1987; Sy and Bah, 1987). This integrated approach as an innovation diffusion tool consists of a process which spans the field level through to the transformation and marketing of derived products on the world market. In the agriculture sector, in which this tool was mainly applied[21], vertical integration gives power to industries by giving them the role of mediators of innovation as well as the role of providers of insecticide, inputs, and credits etc. Within this approach, the firms provide farmers with

[20] It is how it is called in Burkina Faso to reflect the Top-Down or linear model. There was no input from the farmers.

[21] Before the agriculture sector it was the health sector where this approach was usually implemented. (Rifkin, Kangere; Fournier and Potvin, 1995)

everything they need to grow their cash crop and are reimbursed by the farmers after harvest. This can be a standard price relative to every farmer's need, who then reimburses what is used. In addition, research institutes, who conduct research to solve difficulties related to developing the growth crop, interact only with firms (industries) and not with farmers (Belloncle, 1987). The research institutes were oriented towards real problems and conducted field trials before any diffusion[22] was undertaken (Mahdavi, 1987; Pickering, 1987). Researchers are informed of the needs of farmers by the technical support agents used by the firms. Therefore, in this approach to the diffusion of innovation there is a focus on the group of farmers at village level. The technical support agent's attention is on the sharing of experiences learnt from their training and interactions with other farmers and researchers and attributing roles for the effective transfer of new technology. There was no direct, simultaneous contact between technical support agents, farmers and researchers (Evanson, 1987). This approach to the diffusion of innovation is explained by a researcher as a Top-Down model[23]:

> As I said earlier, it was a Top-Down model. Most of the actors were expatriates. It was called top-down method, that is to say, researchers cede back their findings to technical support agents for diffusion. The Regional Development Organisation (ORD) at that time was affiliated to the Ministry of Agriculture. It was a method which was more or less linear. That is to say, researchers search, find and give results to technical support agents at the Ministry of Agriculture for diffusion; the Ministry diffuses these results to farmers under the ORD framework. Each ORD had an administration. There

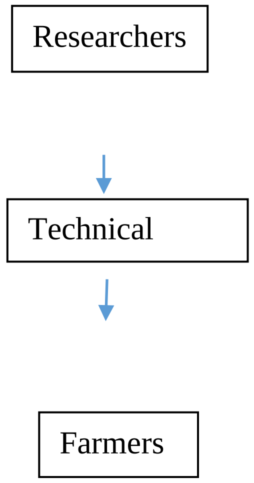
[22] From French word 'vulgarisation' the closest word in English is "diffusion". To make something well known by relevant actors and encourage them to adopt it.

[23] It was Top-Down because researchers findings were given to technical agents who transmitted it to the farmers. Researchers did not expect any feed-back from farmers. The information transmitted to the farmers were therefore meant to work and if it didn't, they concluded that it was the farmers fault.

were five ORDs in Koudougou where I first served in the 1980s. They had their leader with their team of agents who provide training to farmers. These trainers are in direct contact with the farmers, they have their books with all the information to help them to follow up farmers. They were doing so many things at the same time. Not only they are in agriculture, but also they are present in gardening. At the end people were saying that the ORDs were even doing research! (Interview#17).

Conceptually the approach is structured as follows:

Figure 3: Integrated approach around cash crop (Top-Down model to innovation)



Source: Processed by author

Burkina Faso has also applied this approach to the agriculture sector, as illustrated by the following case.

- **Description of an example of Integrated approach around cash crop in Burkina**

In Burkina Faso, this approach was implemented in the cotton sector with regard to the mechanisation of cotton cultivation (Nauleau, 1987). The only cotton firm, SOFITEX, led the project which was implemented in the west part of the country. By adopting mechanisation, cotton farmers became entrepreneurs. The process of implementing the mechanisation started with giving information to farmers who gathered around a single farmer who was successfully using the mechanisation technology. The aim was to make sure farmers witnessed how the technology worked, and through their visits at every step in the process they could see that mechanisation was a useful instrument for modernising the sector. Demonstration days were organised to allow farmers to see different mechanisation strategies, discuss their use and clarify information about the application in order to facilitate the wider adoption of the technology. During these days, information was shared and farmers who wanted to adopt the technology expressed their interest to a committee who later collected relevant information concerning their lands, family, financial situation, technicality, capacity to reimburse credits, agreement to follow rules etc. These applications then proceeded to the next step where an assessment committee decided either to offer financial support or not. When all of these preliminaries were met, further training was provided before farmers could receive their machines. After which ongoing training and visits were provided by the technical support agents for about six years.

Table 8: Increase in the number of farmers who adopted the mechanisation innovation

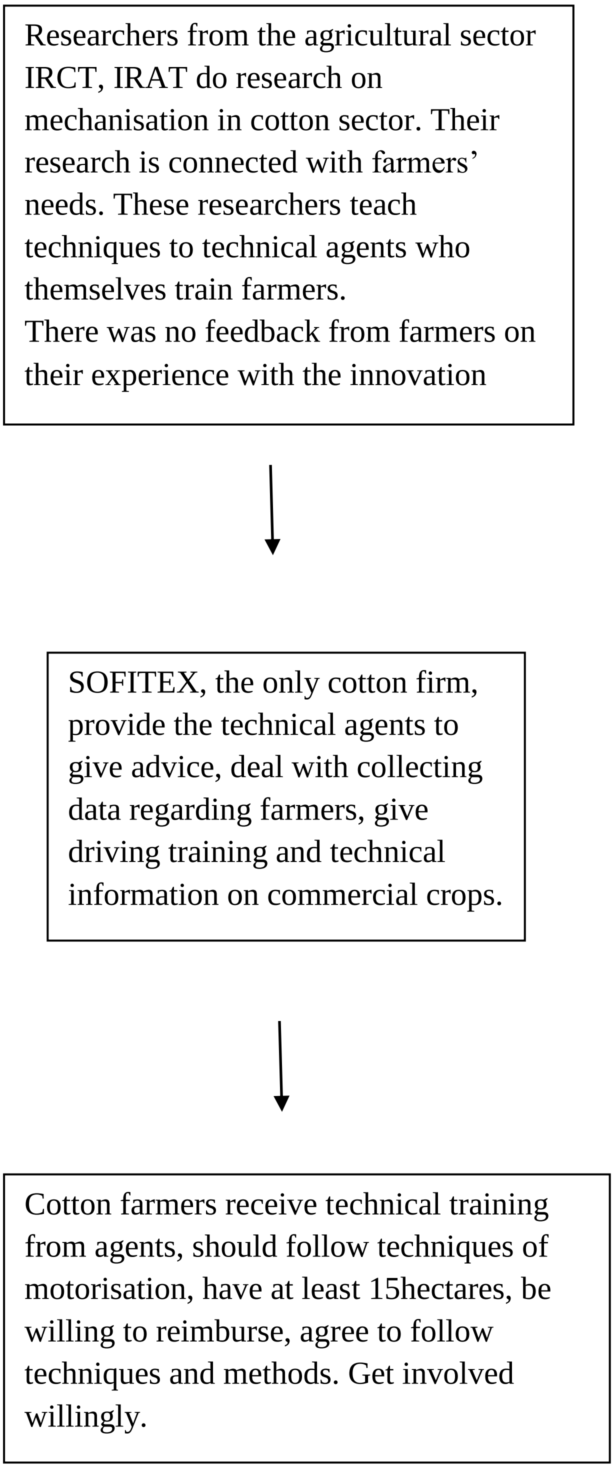
Years	1980	1985
Number of pilot farmers	28	58
Farms' sizes	17,84 hectares	26,85 hectares
Benefits in increased products	7.3%	17%
Benefits in CFA[24] currency	276,073 CFA	1.545.000 CFA

Source : Processed by author from: Belloncle G (ed) Recherche, vulgarisation et Developpement rural en Afrique Noire, 1987, Ministere de la Cooperation

Table 1 confirms that the 'integrated approach around cash crop' as a tool to diffuse innovation in Burkina Faso was a success in terms of increased quantity, larger farm sizes, and financial benefits to a greater number of farmers (Levi and Kam, 1987). Over the five-year period there was an increasing demand which demonstrates a degree of success of the mechanisation diffusion. Experts from the Institute of Agronomic and Tropical Research (IRAT) and the Institute of Research on Cotton and Textiles (IRCT) were involved in this diffusion process. The summary of the practical case is as follows:

[24] CFA francs are used in fourteen countries: twelve formerly French-ruled nations in West and Central Africa, as well as in Guinea-Bissau (a former Portuguese colony) and in Equatorial Guinea (a former Spanish colony). These fourteen countries have a combined population of 147.5 million people (as of 2013), The ISO currency codes are **XAF** for the Central African CFA franc and **XOF** for the West African CFA franc

Figure 4: Integrated approach around cash crop to the implementation of mechanisation in the agricultural sector in Burkina Faso.



Source: Processed by author

This is supposed to integrate farmers' needs, but here it remains very limited in practice. However, such a tool to diffuse innovation exposes the limits of the ways in which the different actors participate in the development of the agricultural sector. The farmers' job is to receive and execute orders and messages from technical agents. They do not participate in building ideas or evaluating their own needs, they are mere *'robots'*. As a result, they are passive instead of self-engaged in the decision making process. In other words, it is an 'empowerment' (Iqbal, 2007:61) of technical agents. It did not matter where the technology came from, and the role of researcher was ambivalent; sometimes they were high level technicians, whose role was to help transfer technology from other countries, generally Western ones. In other cases, they may have undertaken research themselves, but as the analysis below on science policy will show, indigenous research was not taken seriously by the State and there was little funding for research. Researchers played the simple role of high level technicians, which consisted of testing transferred technologies in local conditions before they were diffused by technical support agents to end users.

Early Science and Technology Policy in Burkina Faso: From Colonial to the 1970s

The pre-colonial period up to the 1920s can be considered as a period of development for tropical sciences[25] where it is believed that Africa did not need to 'waste time' on doing research but could instead focus on implementing ready-made technology developed in the North (Gaillard and Waast, 1992). This is also the reason why little research and high-level training were developed in West Francophone Africa during that time. Also, the economic theory of development provided a framework of

[25] From French, 'la science des tropiques' to reflect the indigenous science

conscious organisation of science for development. During this period, the innovation model for science and technology development was linear in theory as in practice, as far as development is concerned. It was through ‘the linear model’ that the process of economic growth was studied. This model explained innovation as depending on scientific discoveries (Manley, 2003). The first linear model considers that high investment in R&D leads to productivity growth (Godin, 2009). This model includes: Basic science, R&D, production, construction and marketing (Manley, 2003).

At the end of the colonial period, there was a real hope for African scholars that science and technology policies and strategies would lead to significant improvement in their living conditions (Gaillard and Waast, 1992). They felt, in French Africa, research was centralised and closely bound to the ’mother country’ (France), but with its new status of independence, Africa might finally be free to organise scientific research fitted to its own new targets. Historically, the 1960s was characterised by many African countries’ political independence. Nevertheless, during that period, scientific policies were still determined to a certain extent by Europe through the development of bilateral and multilateral partnerships, mostly in the economic sector. These partnerships would become a new way of colonizing scientific research in the African continent.

It was from 1970 that African policy makers saw the great role that scientific development could play for the continent’s economic and social development. Even if science and technology strategies remained weak, there appeared to be a new way to frame scientific research policies (Nyerere, 1967; Ki Zerbo, 1973; Yesufu, 1973). The main aim was to make science serve African needs, and make training and research fit into contextual and cultural realities. In order to produce qualified scientists, higher education and advanced training were important (Gaillard and Waast, 1992, Yesufu, 1973, Crossman, 2004). Although, the number of scientists remained very small, there was more freedom in scientific research compared to the colonial period. During the 1970s, the idea of collaboration between research institutes and the university developed. Similar debates about this interaction between actors in the development process and cultural values were being introduced to the scientific debate in Europe (Edquist, 1997; Monley, 2002; Godin, 2009). National bodies responsible for science policies in almost all African countries were therefore emerging and gave birth to national science by the 1970s (Gaillard and Waast, 1992).

Policies in the 1970s focussed on the reorganisation of higher education to increase African competitiveness in the scientific field, yet there was a general policy for all West African countries of defining and increasing the number and quality of researchers and programmes in order to meet development needs. However, political instabilities have considerably affected scientific progress in African countries since the 1960s. From the 1980s different governments started to co-ordinate a policy for scientific research by defining their priority development sectors (Gaillard and Waast, 1992). Before that, there was no significant distribution between fundamental and applied research and different activities and plans related to scientific development were unsuccessful. The ground breaking discussion on 'endogenisation' in the early post-independence period aimed to make higher education fit into African needs and contextual, cultural, geographical realities. The main defenders of this ideology in French West Africa were Hountondgi Paulin, Joseph Ki-Zerbo and Jean-Marc Ela (Crossman, 2004). These and many other scientists across the continent supported this idea of ‘endogenisation’ and they strongly recognised that Africa’s destiny depends on the success of its higher education system which will train the future scientific elites for high quality research. Higher education is therefore a key element in the development of science and technology.

An additional objective of scientific research was to guarantee immediate basic needs (clean water, health and food) for the African population. This policy was supported by an elite committee (Yesufu, 1973) which addressed the way in which scientific research results would be used in order to enhance economic and social development. The adaptation of tertiary education to the African context in both structure and curricula was extensively discussed (Ki Zerbo, 1973; Yesufu, 1973, Crossman, 2004). The policy of promoting scientific research in order to achieve economic and social development in the republic of Upper-Volta emerged in the 1980s. The main focus of the new policy promoted by the independent government for science and technology in Upper Volta (Burkina Faso) during the 1970s was that economic and social development should be supported from a research basis (Jezequel, 2007). In addition, the concept of ‘Africanisation’ became part of the policy in Upper Volta and was strongly supported by Ki-Zerbo (1973) and many others scholars. For them, higher education ‘Africanisation’ would enhance African scientific and technological development and reinforce the availability of African publishing facilities in order to make their scientific discoveries known worldwide (Ki Zerbo, 1973). Moreover, there was an awareness of the need for a solid intellectual base for the consolidation of independence, as well as a means to meet the overwhelming requirements for high-level manpower (Yesufu, 1973). This awareness led different African countries to create their own national universities to promote higher learning in the 1970s. Among them was the University of Ouagadougou, the first and the biggest University of Burkina Faso created in 1974.

In addition, Research and Development (R&D) was introduced by the different governments' agendas. The sectors of research concerned Ethno-sociology, Geography, History, Linguistics, Zoology, and Botany. In addition to the quality and quantity of research programmes, there was an increased number of researchers. It can be understood therefore that science in French Africa was fragile compared to English parts where the number of scientists was far higher. However, in both French and English Africa the focus of research was on the agricultural sector. During the implementation of the post-colonial development policy, the aim was to encourage scientific research related to immediate needs such as food and water, to help counter poverty.

At the end of the 1970s a general movement of democratisation influenced development policy strategies so as to shape innovation diffusion tools with more emphasis on the participation of those for whom the innovation was intended to benefit. This resulted in a shift from the Top-Down innovation diffusion approach to a Top-Down Bottom-Up approach.

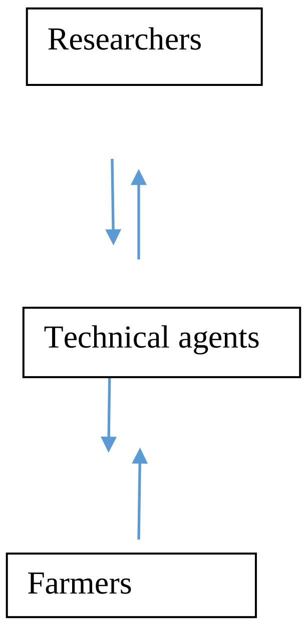
4.3.2. Participatory Innovation Approach: Training and Visits Innovation Diffusion Tool

The participative approach to innovation diffusion, what is called Top-Down Bottom-Up, was developed by Daniel Benor on behalf of the World Bank in the 1970s (Russell, 1987). It consists of organising farm visits by technical agents at a time that is mutually agreeable to both the agent and farmer. An interviewee describes this approach:

> At the end of the 1980s, there was a consultant from the World Bank named Benor who developed a system call TV (Training and Visits). But it was still the same linear process where between researcher and farmer, there is no communication. The relationship is between researchers and technical agents who always meet. The farmer is kept aside, only the technical agent could meet with the researchers. So the linear thinking still exists but there was dialogue between technical agents and researchers during meetings and dialogue between these technical agents and farmers […] (interview #16).

Conceptually the approach is as follows:

Figure 5: Training and Visits innovation diffusion tool (Top-down Bottom-up approach)



Source: Processed by author

- **An example of a Training and Visits innovation diffusion tool in Burkina**

In the early 1980s the government of Burkina Faso decided to include in their agricultural development project a new tool to technology transfer based on "Training and Visits" and in 1982 a national service for technological diffusion was created within the Ministry of Agriculture. In this regard, Burkina Faso was the first country to trial the "Training and Visits" innovation diffusion tool (Levi and Kam, 1987). The aim was for the ministry to lead the diffusion, while technical agents provided training but also provided farmers with credits. What was essential in this new diffusion tool was that it institutionalised the dialogue with researchers. In doing this, a programme was set up to make sure different actors at different levels could express themselves and that continuous training was provided. This tool was introduced in six regions across the country, one of which has been detailed in an article by Levi and Kam (1987) concerning the Hauts Bassins, comprising 365 villages within the ORD (Regional Development Organisation). The concerned ORD involved four research institutes, six offices and 102 diffusion centres with schedules of farms and farms meetings.

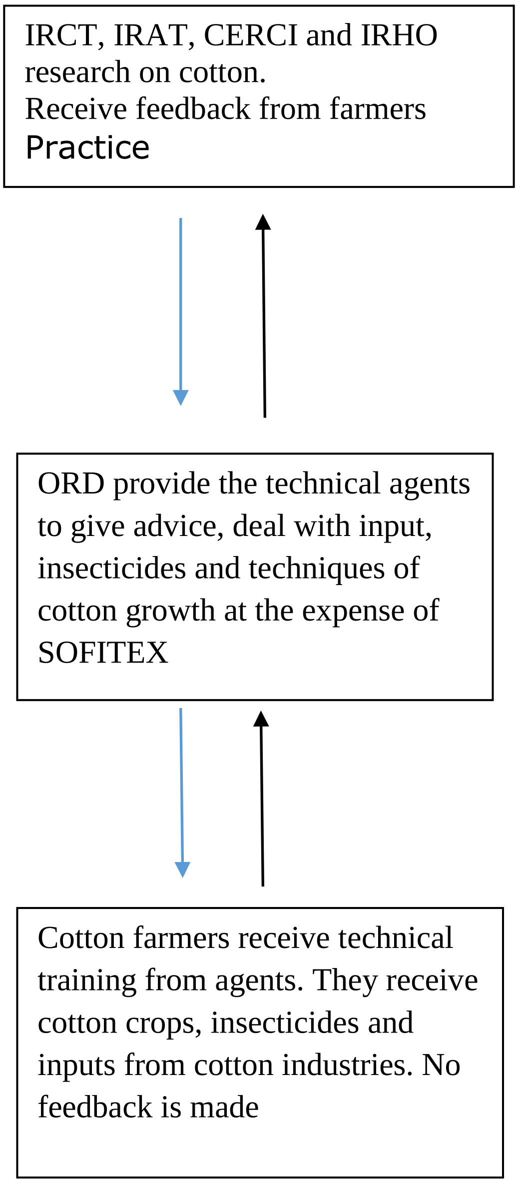
Table 9: Increase in the number of actors involved in the Training and Visits innovation diffusion tool

Years	**1979/80**	**1983/84**
Technical agents	50	105
Number of farmers	108	288
Number of groups of farmers	18	36

Source: processed by author from: Belloncle G (ed) *Recherche, vulgarisation et Developpement rural en Afrique Noire, 1987,* Ministere de la Cooperation

It appears that farmers have appreciated the continuous and ongoing visits from the technical agents. At the same time the ongoing exchanges between technical agents and researchers makes them feel they know their job better and what to do at every stage. There is mutual respect between technical agents and farmers. The ORD are also satisfied because of the independence they gain in the distribution of insecticides etc. In addition, researchers' findings can be diffused to farmers and thereby give them more choices. A summary of the approach is presented below.

Figure 6: Training and Visits innovation diffusion tool to the implementation of commercial crops in Burkina Faso



Source: Processed by author

However, there could be problems as discussed by one interviewee: "the technical agents were supposed to transmit farmers' enquiries to researchers but this never happens or if it does happen, the message is transformed at the end" (Interview#16). In this approach, the problem of participation remains crucial because the level of participation was low or even non-existent. Indeed, in general, by definition, "First, participation has to be active. Secondly, participation implies that people have the right and the responsibility to make choices and therefore have power over decisions which affect their lives. Thirdly, mechanisms have to be in place to allow the choices to be implemented." (Bjaras, Haglund and Rifkin, 1991:200). These conditions are not met in this Training and Visits innovation diffusion tool where wrong messages are sometimes transmitted by technical agents who are situated between researchers and farmers. As a result, in practice, farmers and researchers never meet even though technical agents were working as intermediaries.

As can be seen, the two diffusion tools, "integrated approach around a cash crop" and "Training and Visits, in theory as in practice, remain linear. The main difference being that in the latter communication is improved with feedback from the technical agent who plays the role of intermediary between researchers and end users. Consequently, there was little improvement in the broader science policy regime during this period either.

- **Science and Technology Policy for the People: The Faraco-ba Symposium**

From 1980, important events emerged aimed at boosting economic and social development through a well organised scientific research strategy in Upper Volta. There was a "boom" in the strategy to improve science and technology in Upper Volta and in all African countries. Inter-institutional and scientists' relationships were promoted to facilitate knowledge flows at national and international level (Gaillard, 1999). In this respect, higher education tended to be the centre of those fruitful exchanges. Scientific implementation facilitated research and knowledge dissemination with the aim of emancipating the African continent including Burkina Faso.

The Faraco-ba symposium of 1987 was a significant policy event in Burkina Faso. Indeed, this was the first time Burkina Faso's government defined strategic lines of scientific research which specified the development sectors. This symposium ended in a revolutionary period. The symposium established some directions in scientific research processes and engaged practical thinking in defining research activities in Burkina Faso. Researchers and policy makers therefore achieved: 1) more independence in doing and organising research; 2) linking all research programmes to social and contextual realities and needs; and 3) linking research activities to productivity. These three components constituted the key issues of research at that time and the symposium strategy was to make scientific research serve the real interests of the local society. The major consequence of the Faraco-ba Symposium was the creation of a national scientific research committee in order to help fulfil the above aims. In addition, scientists and policy makers established a strategic plan of action. But this engagement was not to last, as the revolutionary regime who led it was evicted the same year.

Nonetheless, the idea of creating a national science policy to promote development had a deeper influence on the approach to innovation, with thinking on more interactive models beginning to develop.

4.3.3. In Search of an Interactive Innovation Diffusion Approach

It was in the 1990s that the terms "innovation network", "research optimisation[26]" and "local use" were introduced in Burkina Faso's development strategies (MESSRS, 1994; MESSRS, 2008; Dakouo, 2008). This led to calls for another tool for innovation diffusion, a system approach known as a 'Farming System' (Belloncle, 1987). This innovation diffusion tool relies mainly on farmers' experiences and beliefs (Bjaras, Haglund and Rifkin, 1991) and therefore encourages their participation in the innovation diffusion process. Farmers are seen as key actors who have their own logic and reasons for doing things, can explain them and should do so. It makes an inventory of the different kinds of existing technologies and employs a systematic programme of trials in stations and on fields in order to test the validity of the findings in the real world at different places. This step involves farmers in the processes. It allows a joint analysis of the results of stations and real farms etc. to be compared before dissemination. This helped to validate new ways of research in order to refine the invention. This is a continuous process where the different actors work together as a system in which researchers are in direct contact with the intermediary technical agents and farmers, as described by a researcher;

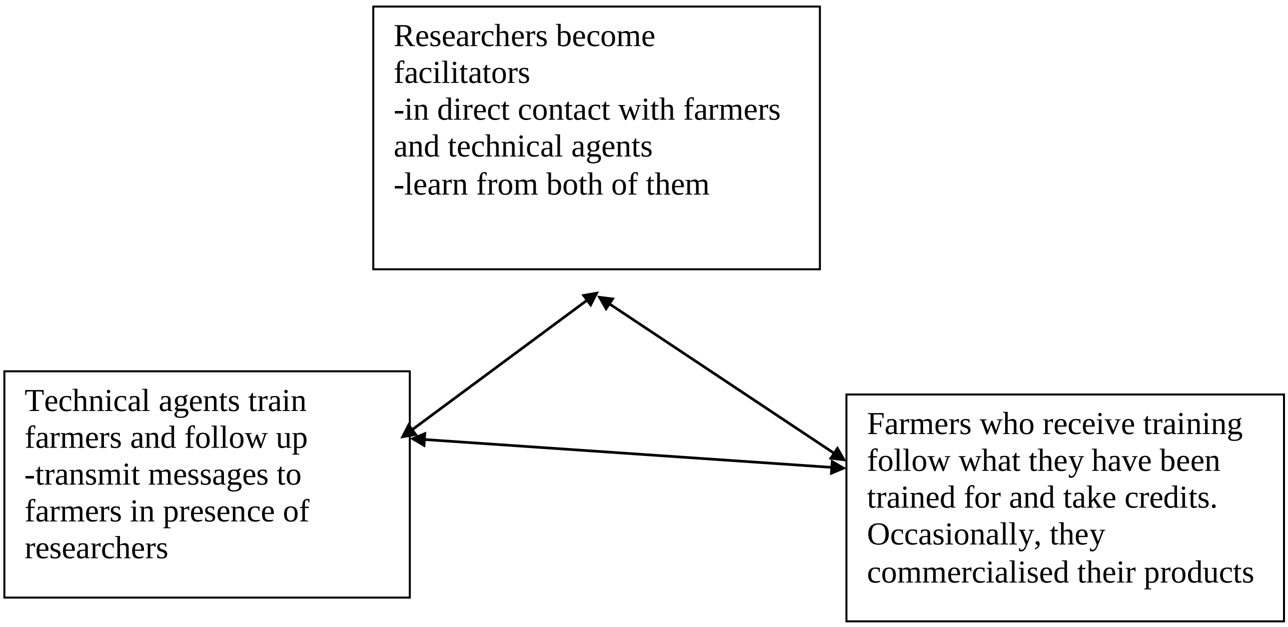
> Yes, the research system appeared in 1985-1990s. It was an integrated research with many disciplines. It was multi-disciplinary. The objective was to assess the technology's agro-ecologic basis and socio-economic impact. It is to see if the variety of 'sorghum' trialed by the research station for example, has the same behaviour at Sissili as well as Koudougou, Yako and Kaya for example. It is to see if the different farmers wherever they are can gain benefits with the

[26] Here optimisation means putting value on an innovation is the same meaning as valuing (valorisation) in French.

technology. There was some kind of small station, called PAPEM. I began my career in research at that time in 1985. The research results were tested in order to validate their agro-ecologic dimension before dissemination stage (Interview#19).

Conceptually, the approach is as follows:

Figure 7: The interactive approach to innovation diffusion



Source: processed by author

In this interactive approach the aim is that "specific groups with shared needs living in a defined geographical area actively pursue identification of their needs, take decisions and establish mechanisms to meet their needs" (Rifkin et al., 1988) cited by (Bjaras, Haglund and Rifkin, 1991: 200).

It is not until 2005 that experiments involving interactive approaches emerge. One is the NIS policy tool, which constitutes the object of this research, and another the Multi-Actor Platform (MAP). The MAP, according to the MRSI (2012a:11), is "a grouping of means (essentially equipment and human resources) for a specific open community where users, mainly enterprises, are in interaction with (location of equipment, experimentations of services…) allowing them to conduct their Research and Development (R&D) innovation projects."

The MAP innovation diffusion tool is derived from a farming system which has not been implemented in Burkina Faso. MAP attracted a lot of funding bodies who invested in this domain for its experimentation and adoption (CIRAD-GRET, 2002). This perspective of the Dissemination of New Agricultural Technologies in Africa (DONATA) project attracted the Ministry of Agriculture to adopt such a tool. This innovation diffusion tool, which brings together researchers and actors from the rural world involved in a value chain, was implemented in Sissili (a region in Burkina Faso). The objective of the Innovation Platform in the case of maize was to optimise the adoption of agricultural technology including farmers' innovations and good practices (Millogo, 2013). In other words, the MAP

> constitutes a tool for multiple stakeholders (producers, users, traders, technical partners, etc.). These actors with common and / or divergent interests, are called to learn, innovate and act together in a systemic way. Indeed, this framework will be a space for dialogue and the search for actions to development. It aims to strengthen producers' decision-making capacity, and ensure the sustainability of their farms (Millogo, 2013:5).

As can be seen in contrast to the NIS diffusion tool, which is the case study of this research and which is going to be developed in the following chapter, the Multi-Actor Platform tool is embedded in the logic of the 'farming systems' (Glin, 2010). The main innovation in this approach compared to the 'integrated approach around cash crops', 'Training and Visits' tools, is its heavy use of utilitarian economic principles in its framing. For example, all involved actors are supposed to have interests beyond humanitarian interests for getting involved, and farmers in particular can negotiate with the other actors what they think is relevant for their business (Glin, 2010). Communication is also improved as all actors can communicate with each other either in groups or individually. As with the two previous approaches, it is in the agriculture sector that this interactive approach has been trialled. It partially replaced the old participative diffusion approach, but still operates within the same sector with almost the same actors, as the researcher who brought it to the Institute for Environment and Agriculture Research (INERA) practiced both previous approaches. The story of the experimentation of the approach in Burkina Faso is best told by a researcher involved:

> From 2006, there was funding coming from different levels and in 2007, the CORAF which is the main institution for innovation in the sub-region of Africa, and which depends on FARA, the African Forum. CORAF, which is affiliated to all the different research institutes in Africa, made a proposition concerning a new method of linking research and human [interaction] What is sure is that it was in December 2007 that we were called to Dakar to be told that in fact there is a new approach for technology transfer and that it is in line with the Integrated Research for Development, in English IAR4D. So they have given us an introduction to the concept IAR4D […] its mechanism for technology transfer is the Multi-Actor Platform which is the context for research and development. We implemented it with Sissili's project with a certain number of actors, well it is probably because of this that you were

> advised to see me. The project was called DONATA: Dissemination of New Agricultural Technology in Africa. It was this DONATA project, which was initiated by the CORAF, and which was implemented in 12 countries, 10 countries in West Africa. […] So the DONATA's project is the key. It was really the development of IAR4D. It was to show that innovation was central in development. We need to innovate; we need to do research in another way and for this we need to link actors, all the actors from the value chain of a product. We needed to link them, put them together, make them enjoy the dynamism, do it in a way that they get involved based on mutual interest. So, we take a product. For example, when I was asked which product we shall use for the project in Burkina Faso, there were three competing products which were candidates: there was rice, maize and cotton […] (Interview#22).

- **Neo-Liberal Science and Technology Policy: The strategic plan**

At policy level, advances were made with the development of the Strategic Plan of Scientific Research in 1995**.** This strategy is the second important event with the aim of coordinating research in all sectors in order to make it more efficient and fruitful for the sake of Burkina Faso's economic and social development. In addition, this strategy aimed to reinforce and create research structures based on the country's needs. Indeed, following the Faraco-ba' symposium, the elaboration of a development plan based on scientific research became a necessity for the country's development. It can be noted already that the institutional focus of the Strategic Plan was not the Universities but the CNRST (CNRST, 1995; 2007). Such a focus was as much about the dynamics of the local scientific community as the influences of international financial institutions such as the World Bank (Kobiane et al., 2012). This Strategic Plan gave a detailed progress of scientific research from the Faraco-ba Symposium up to 1995 and specified all the development sectors and gaps in research that needed to be filled. It consisted of a five-year programme. After the definition of the development problems, the participants in the scientific research plan elaborated the solutions and the strategies needed to solve these problems. However, this period was also one which had seen Burkina Faso involved in the World Bank's Structural Adjustment Programmes, resulting in the freezing of research and higher education funding, although the programme proved insufficient in the face of development challenges (Zagre, 1994). In effect, the financial issue remains to the present day. Funding of higher education and research, as for other sectors, is heavily reliant on international donors, which has an impact on science, technology and development. The Strategic Plan remained partially implemented until 2011, which saw important changes in the organisation of science and innovation for development in Burkina Faso. How then will this socio-technical regime shape the adoption of the NIS as an innovation diffusion tool in Burkina Faso?

4. 4. The Organisation of Research and Innovation

Up to 2011 the Ministry of Higher Education and Research (MESSRS) led research and innovation activities, which was in fact a marginal mission compared to the training mission. Like the different science policies of the time, the existing institutions were considered inadequate to promote a knowledge-centred development policy.

4.4.1. The National Centre for Scientific and Technological Research (CNRST)

The National Centre for Scientific and Technological Research (CNRST) is the main organization for research and innovation in Burkina Faso (MRSI, 2012). At its creation in 1978, the CNRST had five main missions (MESSRS, 2010). First, it proposed to contribute to the definition and implementation of a national policy of scientific, research and technology. Second, it was expected to promote applied research instead of fundamental research. Third, it aimed to coordinate and control scientific and technological research activities undertaken at the national level and abroad. Fourth it set out to elaborate and execute research programs. Finally, it planned to facilitate the diffusion and optimisation of research results. The CNRST is a result of the reform of the Voltaic Centre of Scientific Research (CVRS), itself a product of inherited colonial research institutions (Poussi, 1969). The CVRS is the nationalised name of the French Institute of Black Africa (IFAN) which was created in 1937. IFAN had its headquarters in Dakar and a branch located in Burkina Faso since 1949. It changed its name to CVRS in 1965 (Lill and Gaillard, 2013). Long before IFAN, the French set up the first experimental agricultural research station of Saria in 1923 at Niangologo in the western part of Burkina Faso (Notes Africaines, 1961).

To date, the CNRST is made up of four Institutes namely the Institute of Environmental and Agricultural Research (INERA), the Institute of Research in Applied Sciences and Technology (IRSAT), the National Institute of Social Sciences (INSS), and the Institute for Research in Health Sciences (IRSS). In addition, the Strategic Plan of Scientific Research of Burkina Faso, was developed in 1995 by policy makers, national and international scientists and specialists, aimed through the FRSIT and ANVAR to adopt innovations able to support the country's development (Université de Ouagadougou, 2004). Therefore, it acknowledged research as important for development and charted the course that future research needed to take. It was on the basis of this last objective that the national Forum of Scientific Research and Technological Innovation (FRSIT) was created and institutionalised in September

1995 (FRSIT/CDRI, 2008) to promote the use of research results and innovations at national and international levels, and to encourage research collaboration through biennial events.

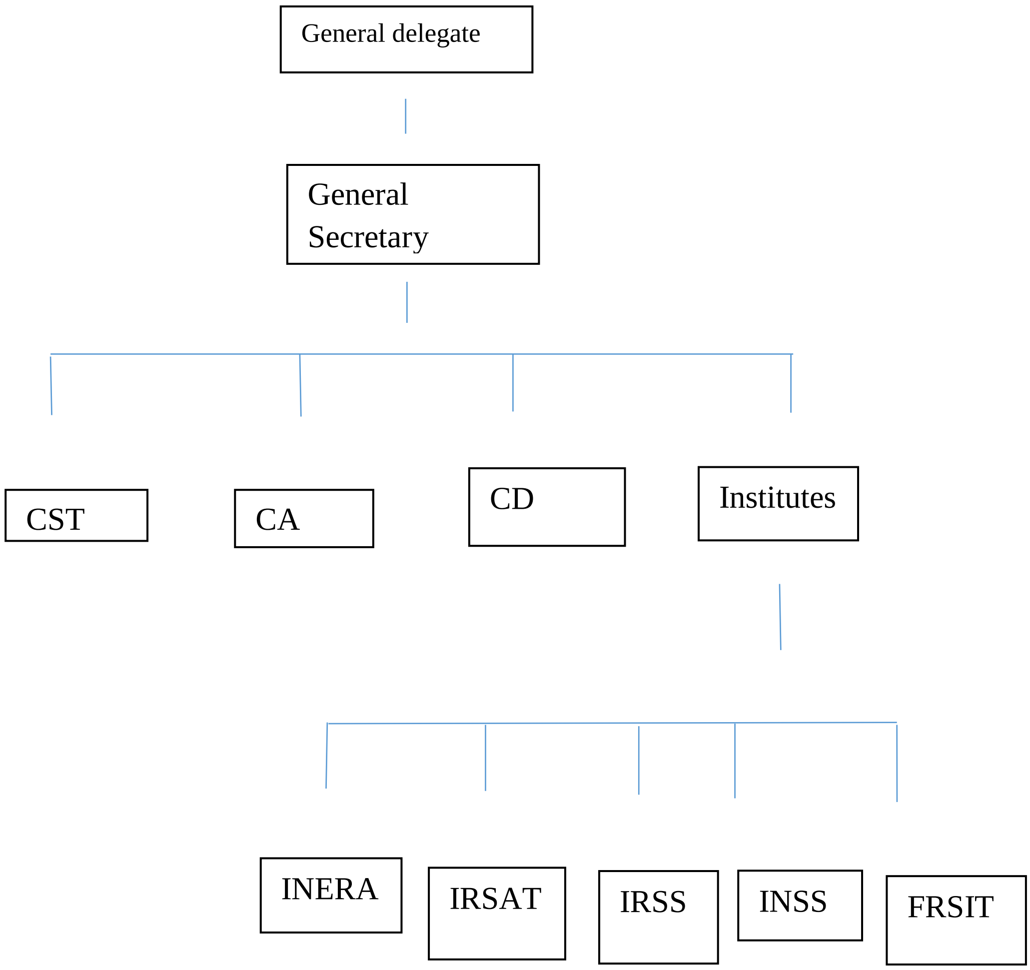
To fulfil these aims, The National Agency for the Use of Research Results (ANVAR) is the sub-structure created in 1997 whose task was to promote the use of research results generated in Burkina Faso, neighbouring countries and worldwide (FRSIT, 2009). This national agency's mission is to make sure that the research results promoted by FRSIT gain better recognition, thus allowing research and innovation results to have a positive impact on the economic development of the country. Under ANVAR's mandate, any innovation can be adopted if the technology is considered useful for solving problems faced by the country (CNRST, 1995; FRSIT/CRDI, 2008; FRSIT, 2009).

CST: scientific and technologic committee

CA: administrative committee

CD: direction committee

Figure 8: National Centre for Scientific Research organisational framework organisational framework



Source: Processed by author

4.4.2. Technical Agencies and NGOs

Apart from the formal system of scientific and technological research (CNRST), other ministerial departments carry out research in various areas (MRSI, 2012). For example, the Centre for Health Research of Nouna and the MURAZ Centre, under the

Ministry of Health; the National Research Centre for Forest Seeds (CNSF), under the Ministry of Environment and Sustainable Development; and the Office of Mines and Geology of Burkina (BUMUGEB), under the Ministry of Mines, Career and Energy. In addition, other regional, international funding bodies and NGOs support higher education and research activities in Burkina Faso.

4.4.3. Organisation of Higher Education

Higher education in Burkina Faso is led by Universities. The main public University is the University of Ouagadougou with other public and private universities. Together they contribute to the training of higher education students. In total, around 1,686 publications from Universities were recorded by university researchers in 2008 (Dakouo, 2008). Since then the number has increased. For the academic year 2010-2011, the Universities counted 60,998 students in total for higher education with 6000 teaching staff (Kobiane et al., 2012). Among the 60,998 students, 83% are from public universities and only 17% are from the private universities (Ministère des Affaires Etrangères et Européenne, 2011). M.A. and doctorate training only started in 1994, 20 years after the first University was created, with only MAs in economics. In 2009, there were 30 doctoral programmes (Some, 2009). Research conducted in universities is primarily focused on advancing researchers in their respective teaching/research career. Therefore, R&D is not a priority in these institutions (MRSI, 2012).

Moreover, there is limited financial support for research. As stated by one official:

> you know that the State does not support research, in spite of the fact that the State pays the salary of researchers, the buildings and water as a well as

> electricity bills, the State does not do anything at all. You can imagine how dependent we are towards external support […] these funding bodies come with everything set, we just have to follow. Since when have you ever seen a country which develops based on this? […] (Interview#16).

Indeed, many financial partners have been involved in scientific research, development and research results validation and use in Burkina Faso, but, pure research is still predominant (87,6%) compared to applied research (11%). Only 1.4% deals with both (MESSRS, 2010). The research budget from the government in 2008 was 33% compared to 25% for training and 67% from partners. Since the Structural Adjustment Programmes adoption in Burkina Faso, the grant allocated to students has decreased considerably leading to the creation of the funding body (FONER) in February 1994 to help students with financial support and loans (Lill and Gaillard, 2013). As of 2012, 60,000 loans have been distributed to students. In the research area, government financial support remains very low. The predominant research area is agriculture, which appears to be the main development sector in developing countries in general.

Before 2011, the CNRST and the Universities were coordinated by the same ministry, namely the Ministry of Higher Education and Scientific Research (MESSRS). In early 2011, the scientific research branch of MESSRS was detached to constitute a new ministry, the Ministry of Scientific Research and Innovation (MRSI). Then it became the Ministry of Secondary and Higher Education (MESS).

4.5. Conclusion

The aim of this chapter was to investigate the crisis of successive socio-technical regimes in Burkina Faso through policy shifts with respect to innovation diffusion tools (integrated approach around cash crop, Training and Visits, Farming System). These changes in relation to innovation diffusion were partly a result of increasing pressure from the socio-technical landscape with the rise of the knowledge centred development policy (knowledge economy). These systemic changes paved the way for the adoption of the NIS as a tool to diffuse innovation.

The analysis has shown that successive innovation diffusion tools have each revealed some insufficiencies on the level of participation of the involved actors. In the "integrated approach around cash crop" there was a complete lack of participation by the end users, the farmers, due to a linear process in the innovation diffusion as shown with the mechanisation of the agriculture sector. The end users merely received information and acted upon it. While the "Training and Visits" tool was more participative, it focussed on the role of the technical support agent as an intermediary between end users and researchers. As seen above, the level of participation of the farmers was limited to receiving information instead of an open dialogue between all innovation actors. Lastly, the "Farming System" innovation diffusion tool has prioritised whole-system participation as essential for successful innovation diffusion.

Burkina Faso, which has experimented with and successively adopted different innovation diffusion tools, has found in the latest interactive systemic approach embodied by the MAP tool a means to interest financial bodies. Indeed, the cooperation of international financial institutions has played an important role in innovation diffusion because the adoption of different approaches was dependent on whether or not it was of interest to these institutions. Consequently, due to a lack of funding, it took a long time to diffuse the systemic approach to innovation in Burkina Faso. The role of the state is however becoming central in the implementation of interactive approach to innovation, particularly the NIS diffusion tool, as demonstrated in Chapter 2 (section 2.2.1.3).

The relationship between the strategic policy level and operational level is a methodological one. Since the 1960s the government of Burkina Faso has consistently sought to implement different development policies to improve the economic and social conditions of its people, often in line with state of the art thinking and with external approval, for example from a funding agency. Nevertheless, the results of every new development policy have proved disappointing leading the government to consider adopting the NIS as a policy tool to implement knowledge centred development. Geels' MLP helps explain the diffusion of the NIS policy tool at both strategic and operational levels. Indeed, with regard to the present study, there are three observations to make with regard to the interplay between landscape, regime and niche. The new landscape (knowledge centred development policy) which took over the old one (market policy) put pressure on the existing diffusion approaches (Training and visit) which has become inadequate. This crisis opened up windows of opportunities for the NIS as a new policy tool for innovation diffusion. Under this pressure, the Forum of Scientific Research and Technological Innovation (FRSIT), has been identified as a niche, where, the NIS policy tool is being tested, through a process of learning, with the aim to replace the existing diffusion approach niches are characterised by Geels as the spaces where innovations are developed. The concept of niche will help identify the ‘protected spaces’ where they emerged. The interplay of landscape, socio-technical regimes, and niches provides therefore a coherent conceptual framework with which to investigate the adoption of the framework as a development policy tool in Burkina Faso, and to appreciate how it is shaped through this process. Methodologically, the study of the transition to the NIS as a policy tool cannot be limited at strategic level to how it shapes policy options. It also needs to take into account the appropriation of such a policy tool at operational level. It is this methodological requirement that justified the study of the NIS at both strategic to operational levels.

However, this process need not to follow the linear continuum strategic-operational level. Because, as shown in Chapter 1, from the 1980s, development interventions were thought to be more efficient when done directly at operational level in order to reach the poor, meaning that it is unnecessary for intervention to pass through policy down to operational level. Consequently, the diffusion of the NIS as a policy tool could be adopted directly at this operational level. It was therefore relevant, regardless of the state of the diffusion of the NIS policy tool at strategic policy level, to study its diffusion at operational level in the agricultural sector.

The following chapter will investigate the process of adoption of the NIS policy tool for catalysing innovation for development in Burkina Faso. The analysis will address the relationship between the pressures at the socio-technical landscape level due to the rise of the knowledge-centred development regime in the early 2000s, which opened up the opportunity at the socio-technical regime level for the adoption of the NIS as a new tool for innovation diffusion in Burkina Faso.

Chapter 5: The Shift to the NIS Policy Tool

5.1. Introduction

The previous chapter analysed three different conceptions of innovation diffusion tools, and noted how there was a change in the definition and choice of a NIS diffusion tool in the socio-technical regime in Burkina Faso. As we have seen in Chapter 1, Socio-Technical Landscapes were identified (Geels, 2004), which had implications for the transformation of Burkina Faso's own development policy (Section 1.4.2). As demonstrated in Chapter 4, the socio-technical regimes in relation to innovation diffusion did undergo changes, partly in response to pressures at the landscape level. By investigating the policy shifts with respect to innovation diffusion tools in response to the changes in the country's development policy regimes, Chapter 4 has described the foundation for the adoption of the NIS policy tool for innovation diffusion. The present Chapter will examine the adoption of such a tool for the implementation of knowledge-centred development, as the latest development policy in Burkina Faso. It will make explicit the interplay between the landscape, the regime and niche.

Such a process is outlined by Geels as follows:

> …radical innovations usually emerge outside the regime, in particular market or technological niches. Such radical innovations may diffuse more widely, when several processes link up: (a) external environmental changes, which create pressure on the regime, (b) weakening of the regime, e.g. increasing problems, loss of faith by main actors, (c) stabilisation of the niche-innovation in a dominant design, increasing support from powerful actors, and improving

> price/performance characteristics. If the radical innovation replaces the existing technology, this is accompanied by broader social, cultural, political and infrastructural changes. (Geels, 2007:1412).

The aim of the chapter is first to describe the innovation niche, defined by Geels (2004) as the level or 'area' where the space is provided for radical innovation and experimentation, that enabled the emergence of the NIS as an innovation diffusion tool in Burkina Faso. Second, the chapter also analyses the processes of learning and stabilisation that led to the diffusion of the NIS as a policy narrative, and a tool for innovation diffusion. Finally, this process of diffusion has its own dynamic and needs to be understood in order to appreciate the transition between innovation diffusion approaches. As Akrich et. al highlighted,

> The bringing together of market and technology, through which both inventions *and* the outlets which transform them into innovations are patiently constructed, is more and more a result of a collective activity and no longer the monopoly of an inspired and dedicated individual. The individual qualities of insight, intuition, sense of anticipation, quick reactions, skilfulness, must all be reinvented and reformulated in the language of the organisation. They are no longer the property of an individual, but become collective virtues, during the emergence of which the art of governing and managing play a key role. (Akrich, Callon and Latour, 2002:189)

To follow this collective activity, the chapter will be organised into three main sections. The first section describes the Forum of Scientific Research and Technological Innovation (FRSIT), as a niche within which the NIS as a diffusion tool was nurtured, and outline the context of its creation, mission and organisational set up for innovation management. The second section is about the process of stabilisation of the NIS diffusion tool at niche level, by highlighting the learning processes, the experimentation and the network building involved to stabilise the NIS diffusion tool. The last section explores the outcomes of the innovation process, through an analysis of the institutionalisation of the NIS framework as manifested and applied in policy design.

5.2. FRSIT: An innovation Niche for the NIS as a Policy Tool for Innovation Diffusion

This section is a description of the FRSIT, as a protective niche within which the NIS policy tool was nurtured and tested with the intention of eventually using it to improve existing innovation systems at the regime level such as agriculture in the case of cotton. It describes the FRSIT's context of creation, its missions and its organisational set up for innovation management in Burkina Faso.

5.2.1. Historical Context of Creation

At the beginning of the 1990s, Burkina Faso still faced great development challenges. The successes of the revolutionary policies of the previous decade started to wane while international economic agencies were pressing the country to adopt Structural Adjustment Programmes (SAP) (Zagre 1994). The adoption of the SAP in 1991 had resulted in little improvement five years later (Zagre 1994). In the face of these challenges, the government of Burkina Faso sought new leverage, and turned to the potentially promising area of technological and scientific development. Modest but varied research had been done, however the government and researchers found that "this activity of researchers has long remained unknown to the general public and decision-makers, because of a lack of appropriate policy and communication strategy." (Nacoulma et al., 2005:7).

To rectify this lack of policy and communication between researchers and users of their results, an official meeting was held on 3rd August 1993 between researchers of the University of Ouagadougou, the CNRST (the National Research Centre) and the President of Burkina Faso (CNRST, 1995; Nacoulma et al., 2005). This meeting resulted in the first Forum of Scientific Research and Technological Innovations held between 28th March and 2nd April 1994, under the patronage of the President of Burkina Faso. The success of the forum led to its institutionalisation the following year by a presidential decree (n° 95-347/PRES/MESSRS) on the 19th September 1995. "[The Forum] also marks the engagement of Burkina authorities in facilitating collaboration between users and producers of research for the best utilisation of innovations and inventions" (Nacoulma et al., 2005:2). The Forum would play a focal point in research, invention and innovation promotion for sustainable development in Burkina Faso. In fact, well before the creation of the FRSIT by the Ministry of Higher Education and Scientific Research, the Ministry of Trade, Industry and Craft created the National Fair for Inventors and Innovators (SNII) with the aim of establishing a platform for inventors and innovators from all industries (formal and informal) to make their results available to economic and social organisations. For purposes of efficiency, this fair was integrated with the FRSIT in 2000. With this fusion backed by the two ministries, the FRSIT enlarged and strengthened its framework as a national-level innovation niche and catalyst for innovation in public policy.

5.2.2. The FRSIT's Missions

The FRSIT set out to serve as a platform for actors of research, innovations and inventions, to disseminate and communicate their results and expertise, and record the application of these results by users. In order to achieve this mission, the Forum set out several objectives for the wider communication and dissemination of research results. The FRSIT sought to:

- diffuse the value of the research undertaken in Burkina Faso, or by Burkinabe researchers working for the country and living abroad.
- Disseminate technological innovations;
- Regularly and consistently communicate information on technological innovations to the public

It should be observed that, the idea of adopting a more effective strategy of diffusion was established around the period (1995) in Burkina Faso. The innovation model for science and technology development, which was dominant in the 1950s, 1960s, and even 1970s, was linear. This model explained innovation as depending on scientific discoveries. If every innovation begins with these discoveries, Science is seen as the main actor in the development process (Manley, 2003). The first linear model assumed that the high investment in R&D would lead to productivity growth (Godin, 2009). This model includes basic science, R&D, production construction and marketing. All of these elements are thought to be acting in a linear way (Manley, 2003). It is for this reason that the linear model is called the "Science-Push Model" and then "Demand-Pull" when focused on the demand side of the process (Manley, 2003). In a way, it was a period characterised by scientism and technological progressivism, consisting in attributing an intrinsic instrumental role to science and technology (Kleinman, 2005), thus making any idea of purposive communication around research results is not relevant The trend in FRSIT strategy in terms of diffusion reflects then a broader shift in innovation theory, although not purposively articulated by actors in Burkina Faso. As Rogers (2003:5) explains, “diffusion is a process in which an innovation is diffused through certain channels over time among the members of a social system”. In Burkina Faso, in the 1990s, the development agencies were striving to develop more interactive approaches for innovation diffusion. As one official stated, “Promoting communication is essential to deal with the development issues of the time” (Interview #01).

Secondly the FRSIT sought to strengthen scientific communities through education and professional development by:

- Guaranteeing the quality of research products given to the consumer,
- Establishing strong links between researchers and the other actors of technological innovation,
- Evaluating what is gained and the state of research,
- Creating a synergy and reinforcing the relationship between research structures,
- Promoting research and endogenous technological inventions,
- Developing in young people the desire to do research, invent and innovate.

The tendency to think in interactive ways led also to the recognition that each actor in the system needed to be promoted. Research is no longer seen as exclusively within the framework of R&D firms (Some, 2009). In a developing country such as Burkina Faso, the other key challenge regarding the development of a strong research community is the existence of a dynamic but informal research sector, which needs to be integrated within the innovation network and which needs a favourable context in which to promote researchers' discoveries and inventions. The challenge is well expressed by the following statement of a state official who is giving specific examples of behaviour that hinder the diffusion process in Burkina Faso. For him researchers always try to curb the informal discoveries from inventors. Sometimes, they will claim the property right over products belonging to informal inventors and the benefits associated to it. This lack of trust has aggravated due to State weakness in terms of law enforcement.

> There is 'KATO' [a private industry]. It makes food for animals… its director is rich. He got loads of work offers from everywhere; for example, the World Bank. There are other funders too. One time one [informal inventor] told me that he has received a financial offer with the help of the ministry, but someone from there has curbed this for his own interest. This guy at the ministry found someone else to copy the same thing. It is really hard for the private informal inventors. […] These kinds of examples are many. Another example is the lady who invented a dish and she wanted IRSAT's [research institute] help in order to get her dish improved, but, IRSAT took her invention and published under the institute name leaving the owner very disappointed […] Few years ago, one of our ministers went abroad and saw the '*bitatore'* [invented in Burkina Faso] and he did not know that it was from Burkina. When he was told that it is from his country, he couldn't believe it […] To tell you that our inventions and discoveries remain 'under the roof'. It is shameful but that is the reality, it is a matter of mentality. There is definitely a need for a real change. As for now, we are in this situation because, the owners of the technologies are very scared, as they are at risk to see their inventions and innovations being stolen by other strong actors (Interview #9).

A further set of objectives focuses on the need to involve policy-makers in a more systematic way in innovation promotion. To this end, FRSIT sets out to:

- Raise the interest and commitment of the national and international communities in the current research programmes in Burkina Faso,
- Involve the development partners in research in a dynamic way,
- Attract research partners and encourage the promotion of technologies, diffusion of research results and research funding
- Encourage policy makers to appreciate research on a concrete level in order to shed light on their strategic choices.

According to another official, this is to say that:

> The FRSIT in its conception is a tool of dialogue [that is to say a tool which create incentives for collaboration and networking] between the different actors such as researchers, inventors-innovators, decision makers, industrialists, producers of research results and other research partners. In this dialogue, researchers and the inventors-innovators are expecting a better promotion of their findings and opportunities of scientific cooperation and business networking. Policy makers need trustworthy scientific data to make sure that their decisions are pertinent to efficient resources for research concerning the funding agencies and the producers. The FRSIT is conceived to assess the possibility of using research results, inventions and any innovation undertaken (Interview#3).

Until the creation of FRSIT, the policy aspect of innovation systems had been neglected. Indeed, as described in Chapter 4, not only were the innovation diffusion tools limited to the micro-scale but also, they consisted in the diffusion of technology developed for farmers, either locally or internationally by low level technicians. At best, these innovation diffusion tools tried to increase the degree of participation of the users and involve local craftsmen in the maintenance of the diffused technology. The broader social context which would have brought forward the policy aspect was neither explicitly present nor considered relevant to the innovation process. At the beginning of the 1990s, such considerations appeared inadequate for solving the complexity of innovation processes. A broader approach was urgently needed, which would also allow politicians to be aware of the important role of science in international relations.

5.2.3. FRSIT's Management

The FRSIT as a technological niche is an organised space (Geels, 2004; Geels and Kemp, 2007). The performance of technological niches in terms of nurturing innovations depends on their human resources, organisational set up, organisational positioning, and networking capacities (Geels and Schot, 2008). At its creation the FRSIT consisted of administrative and scientific functions. The former is led by the Permanent Secretary, nominated by the Minister of Higher Education and Scientific Research (MESSRS). His role is in line with the objectives of FRSIT. As an institute, the FRSIT possesses three services: the administrative and financial service, the service for creativity and invention and the promotion and marketing service. The role of these services is:

- To inform the public and the researchers on the FRSIT and its activities,

- To raise the profile of FRSIT through media and other useful means of communication both regionally and internationally
- To participate in resource mobilisation in order to organise the forum and mobilise actors.

On the other hand, there is the scientific committee headed by a general delegate of CNRST with scientific members from universities and research centres, ministerial departments, NGOs and regional research institutes.

The role of the committee is:

- To define the themes of the different editions,
- To propose the themes of these editions,
- To follow recommendations derived from the discussions during the forum.

One of the main duties of the FRSIT is to organise a forum every two years whose theme is chosen by the scientific committee. Its aim is to give an opportunity to every actor, from around the world whose work is of relevance to Burkina Faso, who is interested in research or technological innovation to participate in order to share his/her research results with a wider public at national, regional and international level. As stated by a former Permanent Secretary of the Forum during an interview, “it is like that, every two years the scientific committee together choose a theme and the date is fixed for the forum. You see, at this event everyone is present: those who [have] got something to show and those who come to look at the inventions.” (Interview# 19). However, it’s paradoxical that with the political interest in the forum, as evident from its mission and objectives, the Forum is financed by non-governmental organisations. Key financial partners are the Ford Foundation, the Rockefeller Foundation, CRDI, CTA, the European Union, US/AID), Union Economique et Monétaire Ouest Africaine l'UEMOA etc (MRSI, 2012). Another perspective on this funding support is that FRSIT has established itself as a key player in the network, and is valued both internally and internationally.

5.3. The Adoption of the NIS Policy tool

5.3.1. The Need for a New tool to Innovation Diffusion

The need for a new tool for encouraging innovation diffusion was recognised in the early 2000s. At the end of the 1990s, after different development policy shifts, the development indicators still showed unsatisfactory results (World bank, 1999). Chapter 1 gave a very detailed description of the different development policies developed for the socio-economic development of the country which for a long time has experienced persistent underdevelopment. Such a situation has not improved despite different efforts, among them, the Strategic Plan for Scientific Research in 1994 and the National Forum for Scientific and technological Innovation in 1995, which were put in place to foster the country's socio-economic development. As shown in the evaluation of the FRSIT in 2005, development actors were still struggling to meet their goals (Nakoulma et al., 2005).

It appears from this evaluation that the Forum's ability to promote innovation development remained low. Other difficulties were identified by the organisers of the Forum including 1) the different actors (researchers, inventors, innovators, policy makers and users of research results) work in isolation from one another so that results are neither shared nor widely disseminated; 2) The same actors are ignorant of the needs of the users of their research; 3) there is no framework for actors; 4) there is no dynamism in scientific and technological research; 5) the good work done by isolated innovators in mechanics such as, food, energy, GMO, small private enterprises are not well known. Finally; 6) women do not occupy their place in innovation promotion despite their important role in food and cosmetics (Nakoulma et al. 2005).

As can be seen, the main gap is the lack of synergy between actors who are meant to work in a system. Indeed, there is no perceived link even between actors of the same group. For example, though they both belong to the same research centre (CNRST), results are not shared between the agricultural research institute (INERA) and the food research institute (IRSAT) (FRSIT/CRDI, 2008). However, the information flow between faculties and research units is essential because, this will help actors in the same sectors to know each other's needs through efficient communication. Not only was there a need to implement new development policies, but also to develop new methods to boost technological innovation. It is in this context that the knowledge centred development policy emerged in Burkina Faso. There was a need to identify the existing actors in the innovation systems of Burkina Faso, get to know their needs, constraints, motivations, strengths and weaknesses. In addition, there was a need to create synergy between researchers, inventors, innovators, policy makers, businesses and civil society to promote the value of research results in order to reinforce the capacity of the general secretary of FRSIT to coordinate activities which facilitate dialogue between all the actors. In fact, as the following statement indicates,

> the observation that one can make is that there are in Burkina Faso results and research products and innovations, as well as elements of an innovation system

> capable of significantly increasing the productivity of agricultural systems and bring added value to the direct beneficiaries. However, there is a deep gap between existing innovations and changes implied that this should lead in improving the living conditions of populations. Also creating a synergy of action between the various actors would firstly: identify and understand the needs of users of the results; organize inventors and innovators by area of competence; and secondly: easier access to bank loans; establish partnerships and negotiate contracts; to make political decisions. (FRSIT/CRDI, 2007 :1).

Accordingly, a three years' agreement between IDRC and CNRST was created, entitled the "Analysis of innovation systems and strengthening ties between the actors for socio-economic development of Burkina Faso". Its purpose is to strengthen or create tangible links between the various stakeholders (researchers, policy makers, inventors and media users, private and public) in order to provide relevant material to establish a framework for promoting more ambitious innovations.

However, at this this point there was no clear answer to what needed to be done practically to solve the difficulties acknowledged by FRSIT. This context opened windows of opportunity for the adoption of new systemic approaches resulting in the choice and promotion of the NIS innovation diffusion tool intended for use by both, the government of Burkina Faso at policy level to develop new policy strategies and actors from all sectors at operational level to change the behaviour learnt from old diffusion tools to new ways of interacting which would be informed from the NIS policy tool.

The adoption of innovation is a complex process. Before the technology leaves the niche level to be incorporated within the ST-Regime, it needs to be stabilised at niche level first. In this respect, the NIS policy tool adoption and experimentation at niche level went through a complex process. The actors' learning processes led to the stabilisation of the NIS policy tool framework which transition at the development policy regime offers an opportunity for its adoption. The next section will address the learning and stabilisation processes of the NIS policy tool in the context of Burkina Faso.

5.3.2. Building Social Networks

As indicated in Chapter 2 (section 2.2.1) of this thesis, the NIS framework did not originate in Burkina Faso. it was developed in the 1980s for the OECD countries by Freeman (1982) and Lundvall (1985), as a tool for technological innovation as intrinsically linked to the complex interactions between institutions (Lundvall, 2007). In the case of Burkina Faso, where it was introduced in 2000s, it is a matter of technological transfer; that is to say the "acquisition, development, and utilisation of technological knowledge by a country other than that in which this knowledge originated" (Jafarieh, 2001: 13 citing Derakhshani, 1983). However, technological transfer supposes a definition of a clear problem which will be solved by what is to be transferred (Akrich et al., 2002). At the FRSIT the actors had a clear definition of the problem which needed a solution. Their objective was:

> to facilitate the linkages between the different innovators […] the aim was to find a strategy in a way that innovations, inventions and the research results which had value during FRSIT's forums being valued at national level. This consisted in making sure that many people get to know the technology and then adopt it (Interview#10).

In other words, as clearly stated in the workshop report,

> there are links between the different actors that need reinforcement. Facilitating access to inputs, equipment is the result of personal relationships. The technical and financial partners and the state support very little research / development. Appreciation of support enjoyed by actors to promote innovations in the pipeline. The state is the main supporting actor. Supports transformation are more important than the production level» (CNRST, 2009: 3).

In order to find a solution to this problem, having long worked with FRSIT as a financial partner, the IDRC offered to provide a substantial financial support, because the type of problem exposed by the FRSIT actors was part of its area of interest[27]. But this financial support was subject to the submission of a proposal which followed the IDRC's funding policy. In this chapter, the word project refers to three meaning according to the context.

- Project as a grant application
- Project as development project or intervention
- Project as the specific case of NIS

In Burkina Faso, as in many developing countries, the wide spread of development projects has led many local people to consider them more as opportunities for

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[27]The experience of such an agency of the NIS framework goes back to the 1980s through Mullin James who before he worked for IDRC, was a former Chair of the Committee on Science and Technology Policy at the OECD. It was within such committee members that the NIS framework was developed in the 1980s. However, IDRC has recognised the possibility of the transfer of such technology to an Africa context since 2003 when, after it created the regional advisers commission in 2001, the regional office met with its 10 members and discussed on the possibilities of stimulating the use and importance of research results for fruitful decision making in an African context. Since then, 2004-2007 was mainly the time to look at specific cases. The series of meetings of regional advisors with researchers and policy makers from different countries was a way to acknowledge different points of view and look at obstacles which hinder the dialogue between development actors with reference to every country's specific realities. As can be seen, it was within this period that the project on the NIS between FRSIT/IDRC was built. Its representative Dr Innocent Butare advice local actors on the effectiveness of a new approach which could help solve the underline problems

individual gain and self-promotion through money making from funding bodies than as means for solving development problems. In addition to being in line with their area of interest, the project (grant application) should be developed through a participative process involving IDRC's experts in order to come up with a mutually agreed project. As the leader of the national project team member stated:

> [Ever] since its creation after the first forum in 1994, I led the FRSIT and every two years at each different forum, CRDI has always been a financial partner. It has given us a number of donations, 10 to 15 billion at each forum. Because of this constant financial support, I discussed with the minister what could be done to acknowledge it. I proposed an award to the director because it is in fact the director who was responsible, and the outcome could have been different if there had been a different person in charge. At that time the director was unable to come and was represented by one of his employees who received the award on his behalf. He took it back to Canada and presented it during their general assembly. People at IDRC were really happy about the recognition that we showed through the medal which will never disappear. Then he [the director] came and said, we were making innovations, and that we needed to elaborate the project [grant application] so that they can give us a 1 billion in CFA for such a project on the innovation systems. This is how the idea was born […]. You see, it is a story, it is a philosophy, it is a system, it is a whole vision (Interview#28).

In response to this offer, according to his understanding of the problem to be solved, the head of the national team at FRSIT set out to build an appropriate team for the project's development. He gathered five other researchers from various academic backgrounds and institutional affiliations to work with him, a total of six members with life and earth science backgrounds including two social scientists. Only two members, both from life and earth science, were affiliated with FRSIT. They drafted a project about the "*Promotion [advancement] and use of technological inventions and* *innovations in Burkina Faso by the FRSIT"*[28]. An analysis of the underlying assumption in the framing of the project shows a definite break with old innovation diffusion tools as described in Chapter 4. However, there is no indication that they were aware of the NIS tool for innovation diffusion. At best, the assumption and the framing are closer to an approach developed by the IDRC in the early 2000s published under the title, *African Researchers and Decision-makers: Building Synergy for Development.* The idea of heterogeneous actors (policy makers, researchers and users) is present, the idea of a network and or a system is present and the idea of communication between these actors is also present from what follows. In sum, this appears as a network. Even if these aspects are present in the NIS policy tool, there is no evidence from the draft that their inspiration came from it.

This proposal was submitted to the IDRC during the year 2006. I understand that "Dr Butare was the leading actor in the project at IDRC" (Interview #9), who received the project from FRSIT and submitted it for analysis. Analysis of the internal process at the IDRC shows that there was a different interpretation of the proposed solution to an interactive tool from the national team at FRSIT. From the IDRC's analysis of the underlying assumption of the project, they decided that the NIS policy tool would be the best solution to the problem regarding the fact that there were no linkages between users and producers of knowledge. A representative at IDRC stated that "it is obviously from us, let's say […] I had to make the proposition because locally the concept was not known at all by national actors" (Interview#47).

[28] Draft proposal access from an interviewee, member of the national team

Feedback was sent to the national project team advising it to revise its proposal by framing it according to the NIS framework. However, as shown above, the national team lacked expertise on understanding this framework, then use it as a policy tool. IDRC offered technical support, in the form of an expert in development who is also from Burkina Faso. As one of the team member observes:

> Yes, yes, I will explain to you how the IDRC works. If for example they have an activity, they have their experts who work with them. This person is in the company workers' list in different domains. There are some people in the list who are marked in red because they have failed to do previous tasks. So IDRC always has to give its point of view even if you propose an expert. In our case, we did not propose anybody. But [name], has been working with IDRC for a long [time] and so he was proposed by the IDRC to assist us (Interview#11).

This expert was expected to advise the national team in order to meet the IDRC's guidelines. After several rounds of submissions and feedbacks, the project was revised accordingly and then funded. One of the national team members describes the process as follows:

> Each of us has contributed to the writing of the project [grant proposal]. I think it took almost a year before it was accepted, because, when we write we send and the IDRC say, you need to do this, we correct and then send back again. At some point, the boss said we should leave it and I said we are going to do it until the end, because, if we don't, they will say, 'look we wanted to help them with a project and funding but they did not want help'. Then we continue working and then one day, I think it was just before Christmas the boss [referring to NIS project manager] said he has received a message which says that the project was accepted. That is it! we've written and their experts have accepted after many drafts (Interview#39).

The final version of the project was entitled *'Analysis of the Innovation Systems and Strengthening of Linkages Between Actors for Socio-Economic Development in Burkina Faso'*. Based on preliminary analysis of the existing systems The focus was to draw a policy tool in light with the NIS framework The IDRC consultant explains their involvement in framing the project:

> Here it is, it is FRSIT which submitted the project but in fact, it is the CRDI [IDRC] which has done a lot of work on the subject [NIS], because, as I said, there was [too great] a lack of competence in the matter locally to allow local actors to make such a formulation of this kind of project. Therefore, the CRDI through its experiences said look, there are some existing approaches which fortunately can be used here if you take the opportunity and the necessity of coordination between the different actors who are involved in the system to create value chains... (Interview#7).

The IDRC representative recalls "As I said earlier, I proposed this idea of the NIS, they [national team] did not have knowledge on the matter" (Interview#47).

The framing of the project by the IDRC using an innovation perspective leaves two options. One is that the IDRC takes over the lead of the project at the expense of the national team. Because, in practice, by reframing the solution to the problem, IRDC makes itself in Callon's words "an obligatory passage point" (Callon, 1986). Its power in the network increases as its role changes from that of an external funder to that of an internal technical advisor. The other option is that the national team be trained on the NIS framework allowing them to lead the implementation of the project [the NIS as a project]. This latter option will enable both parties to advance their interest though with a shift in power relations. Although the IDRC has expertise in implementing the innovation systems diffusion tool, it was not equipped to conduct a training course on the NIS concept, thus, an expert from the United Kingdom[29] was recruited by the IDRC for this purpose. The course was designed in two parts. A theoretical part consisted of learning about the NIS as a concept, and its application as a tool in four case studies.

> The training in the use of the framework as a tool for innovation systems building […] aims to give specific knowledge to the project team and other partners. This is the theoretical part of the concept. The training therefore aims to give to the team some tools to collect and analyse data for the analysis of the existing innovation systems of maize, millet, mango and shea which are chosen in the framework of the project in order to reinforce it, in light with the NIS model (Interview#14).

The objective was that the findings from these analyses can be used to make policy in some ways.

Table 10: Training content

Introduction to the Innovation Systems	Analysis of Innovation Systems	Method and case selection
-Concept Origin - Definition of NIS terminology -Main components	Central elements - Evolution of the concept - Analysis of the agricultural sector	-Lessons from other case studies on cocoa from Ghana -Case studies on maize, millet, mango, shea, -Clear plans on how work will be conducted

Source: Processed by author

[29]Dr Watu Wamae a Kenyan national, holds a PhD in economics of innovation and development and is a visiting research fellow in the Department of Economics, Faculty of Social Sciences, The Open University, UK

In addition, the training included participation in conferences and continued international training to strengthen what had been already learnt. For instance, attendance at the III International Conference on KMA "Knowledge Management Africa" under the theme *Knowledge to Reposition Africa in the World Economy.* Moreover, the team leader spent over two weeks at UNI-MERIT[30] in Maastricht with the objective of exchanging information with the UNI-MERIT team on the innovation systems, discussing draft papers from the case studies, looking for possible doctoral, masters or short-term training opportunities for his colleagues and students, and finding a possible expert for the mid-term evaluation of the project. The team leader said in this regard, "I even had training abroad to deepen these ideas. It was in Maastricht. In fact, we wanted to meet and learn from experts due to the fact that we needed these experts' advice and impressions on the experience of Burkina Faso. I did meet with them […] there are many other types of training for all the different actors or some specific ones undertaken locally" (Interview#28).

Through this learning process, one can conclude from the above analysis that the NIS policy tool reached relative stabilization. Through the setting up of appropriate networks and undertaking training on the NIS framework, the local team managed to meet the standard of IDRC. However, this does not mean though that the NIS policy tool has stabilized at the niche level, such that it will automatically be adopted by the

[30]United Nations University - Maastricht Economic and Ssocial Research and Training Centre on Innovation and Technology with key reference people such as Luc Soete, a professor of economics and director of UNU-MERIT, Maastricht University and his collaborators. The UNU-MERIT course on the Design and Evaluation of Innovation Policies (DEIP) is an intensive one-week programme for policymakers in science, technology and innovation in developing countries and for participants from the private sector involved in strategic decision-making about technology and innovation. UNIT-MERIT director, Soete L has published number of books and article with NIS funders such as Freeman on the national innovation systems. This university is well known for its expertise on the matter. IDRC's director was aware of this and proposed the national team director should spend some time with them.

relevant actors. In order for the NIS policy tool to spread and become a common tool for relevant actors at the socio-technical regime level, it needs “windows of opportunity” (Geels, 2004: 915). Such “windows of opportunity” are created by the need for new ways of doing things as a result of pressure from the landscape level (Geels, 2004; Geels and Kemp, 2007). The analysis of the dynamics between the socio-technical landscape and the socio-technical regime in Chapters1 and 4 respectively show the existence of potential windows of opportunity for the adoption of the NIS concept. At the landscape level, after more than four decades of unsuccessful development policies implementation, the knowledge-centred development as the latest policy had been established and needed a tool for its implementation. Therefore, policy makers and entrepreneurs have been looking for new approaches to promote economic performance and social welfare. At the level of the socio-technical regime, the adoption of a new technology supposes there is a problem which needs a solution. In the case of Burkina Faso, policy makers, researchers and users of research results need to know about the NIS concept and that it can be used as a tool to promote their interests. Being aware of this, the actors at FRSIT included in their experimentation strategies, the involvement of all these actors.

5.3.2. Enrolling Researchers, Policy-Makers, Business Actors and the Other Interested Parties

The project described in the previous section was meant to establish the theoretical and methodological foundation for a broader project which aimed at valuing research results. These are niche level actors talk at FRSIT relating to the NIS project. It was a necessary starting point of the project itself because in the context of technology transfer, it was essential to inform the relevant national actors about the framework to be implemented so these niche level actors could convince policy makers, researchers, innovators, inventors and the users of research results who do not have any knowledge on the matter. According to one of the national team members this part of the project was named:

> The little project [a development project], because it was a type of formal framework, where people regularly meet: this is what we want, this is what we got, this is what we want to do, who will do this and that what is the role of everyone […] it was supposed to create in fact a national expertise […] reinforcing communication, knowledge etc. Then, the big project, the project for diffusing it, is the one which should make sure the project has continuity through its institutionalization […] (Interview#13).

Among the range of actors who took part in the process and the adoption of the NIS, two other categories can be identified: the policy makers and the business actors. As explained by one interviewee: "We have invited people from the private sector, people from the transformation side of products. As I said, at political level, there were political representatives. We have invited all of them at all levels and stages" (Interview#23)

5.3.3. Involving researchers, inventors, innovators, users and policy makers

- **Involving researchers**

At niche level, the national team has actively participated in the process of the NIS transfer to Burkina Faso. The team knew at this stage that introducing a new technology required consideration of the social and political context in which it was being introduced if it was to be accepted and successfully implemented. The team also believed that, as with any technology, the social context within which the NIS policy tool was intended to be implemented, was not neutral. That is to say, the new ST-Systems need to displace the old ST-Systems (Geels, 2004). Indeed, for a long time, researchers have collaborated with those who use their research results and therefore already had their avenues for the diffusion of their research results. These former unsuccessful approaches are discussed in Chapter 4. Being aware of these avenues, the national team at niche level adopted a participative approach for information and diffusion, and to show relevant actors the necessity for them to forego their old practices and adopt new ones from the NIS concept to enable them to achieve a more positive outcome from their collaboration which reflect the foundation of the NIS concept. The national team chose four strategic case studies to draw researchers into the process and show how they could improve their networking through the NIS as a new innovation diffusion tool. Researchers participated in conferences, workshops, meetings etc. to strengthen the links between them and the users of their results. This approach also aimed to clarify for the researchers the benefits other actors, (users of research results and policy makers), can bring to them. As explained in the following statement "Researchers would of course get to know the taste of the users of their results, [because] their interests will need to meet those of the users. Then, [working] together in a system any innovation and invention can be successful" (Interview#2). It was a strategy which aimed to establish a dialogue or improve existing dialogues to move from informal to more formal linkages and clarify the advantages for each party for a 'win win' result.

- **Involving policy makers**

The strategy adopted by the national team also involved the participation of policy makers.

This was in acknowledgement that they were crucial to the successful adoption of innovation at the national level and that the previous practices of policy makers needed to be considered in their strategies. With regard to the NIS as a policy tool, thus an innovation diffusion tool, policy makers were invited to take part in a range of different activities[31].

As demonstrated in Chapter 1, development policies implemented prior to the 2000s at the socio-technical regime level were in harmony with the development models at the landscape level. It was from the early 2000s that the rise of the knowledge-centred development model at the landscape level started to put pressure on the policies at the regime level leaving room for new policies. As a result, policy makers who had previously played a passive role in innovation diffusion policy processes became key components in relation to the NIS concept. IDRC representative Dr Butare explained the thinking behind directly involving policy makers in the NIS concept: "[This] gives scientific tools which will help decision makers to take appropriate decisions aiming to facilitate knowledge flow between the different actors of innovation systems and [encouraging] their optimal use to reach goods and services useful for the population" (FRSIT/CRDI, 2008: 7). That is to say that they want their innovation policies to be evidence based. Within this framework, policy makers are considered as the creators

[31]These activities included: 1) training on the use of the NIS analytical tool, 2) participating in a workshop on project launching, 3) attending a symposium on case studies, 4) attending an international conference in Dakar, 5) participating in a workshop for networking with innovation actors; 6) participating in learning exchanges and training at UNI-MERIT

of a favourable social and political context for actors to network appropriately in a formal way (Geels and Kemp, 2007). Therefore, the national team strategy to involve policy makers consisted of both groups examining in collaboration with other relevant actors' ways to create favourable social and political contexts for the diffusion of innovation. This is highlighted by the national team member:

> In fact, it is the policy, which creates these frames for the institutionalisation. So, policy makers create the frame and give a role to such a frame, the way it functions and then define all its mechanisms. That was why in this project we included policy makers. The First Ministry was always invited to all the meetings, all the workshops etc., we made sure that they were invited, and we always ask them to send a representative because, the role of the policy maker matters here. It was very important in the implementation of such processes, so, you can see, the government took part through its representative at every level […]. (Interview#12)

The NIS policy tool as a project was not only desk research but involved meetings, workshops conferences with relevant stakeholders who were invited to contribute throughout. The social context takes into account the power of the institutional and jurisdictional levels to facilitate and accelerate knowledge exchanges and information between innovation system actors. In so doing the team's intention was to create coherence with other development policies such as IPR at the national level to contribute to the protection of inventors and innovators rights.

- **Involving users of the research results including business actors**

One of the NIS policy tool components concerns users who are an integrative part of the system (Geels, 2004). The national team deployed the same method to involve research results users including consumers, traders, industrialists, transformers, business actors, small enterprises, and NGOs, for example, who were enrolled in the process of experimenting with the NIS framework as a policy tool with the intention of them adopting it. The strategy for the national team consisted of examining existing ways in which users accessed research results. In doing so, the national team intended to demonstrate the contribution of the NIS policy tool in strengthening the link between research, innovation and potential. The involvement of these actors is consistent with the NIS policy tool design (OECD, 1999) where they occupy a key role for a functional NIS tool for innovation diffusion. Recognising their importance, the national team set out to explore how they could improve the existing behaviour of users to create a ‘win-win’ situation for all parties.

The above demonstrates that the NIS policy was transferred to Burkina Faso and experimented at the niche level by the FRSIT. The actors who participated in the technological transfer have undertaken a process of diffusion of the NIS policy tool involving different actors who form the different components of the NIS framework. At the niche level, the national team demonstrated through specific case studies (maize, millet, mango and shea), how the NIS policy tool would strengthen existing forms of networking between innovation systems actors for a more positive outcome. The section below focuses on the outcomes of the diffusion of the NIS policy tool for innovation diffusion, at policy level as a policy design. The final part of this thesis sets out to investigate the diffusion of the diffusion tool at the operational level through actors’ behaviour using the case of Bt cotton innovation diffusion and how actors’ behaviour in the Bt cotton case conforms or not to what the NIS policy tool has been designed for.

5.3-4 NIS Institutionalized: The Use of NIS as Innovation Diffusion Tool

Created on the 16th of January 2011, the Ministry of Scientific Research and Innovation (MRSI) aims to support research for socio-economic development in Burkina Faso. As a result, scientific research previously associated with the Higher Education Ministry was detached and named MRSI. MRSI then, hosting research and innovation activities "places particular emphasis on scientific research, technology and innovation as essential drivers for development. MRSI's main mission is to design, implement and monitor government policy towards research and innovation for economic and social development in Burkina Faso." (Lill and Gaillard, 2013: 9). Based on this, its specific objectives target 1) innovation, 2) scientific and technological research, 3) optimising research, inventions and innovation results,

4) facilitating science and technology information and communication, 5) strengthening cooperation between the scientific and the technical sectors 6) supporting the institutional framework of scientific research and innovation, 7) looking for ways for funding scientific research and innovation, 8) putting in place standards and ethics of scientific research and innovation and 9) creating a system for monitoring and evaluating scientific research and innovation (MRSI, 2012). These are the nine key fields for which the MSRI was created. Its creation is intrinsically linked to the CNRST because it was created to give more visibility to research and innovation activities in Burkina Faso and to promote results of scientific research, inventions and innovations.

This statement is confirmed when we compare the objectives of the FRSIT (as described above in sections 5.2.2 and 5.2.3) and the objectives of the MRSI here. There is an underlying similarity between the two sets of objectives with the exception of some details in the wording. As a result, we can agree that the FRSIT as a niche which transferred and experimented with the NIS concept for policy as an innovation diffusion tool has been strongly institutionalised following its institutionalisation through the MRSI. Thus, FRSIT's function has been generalised to make a national framework for innovation and research with the creation of the MRSI. This can be seen as a move from the niche level up toward the regime level.

However, this is not a clear cut conclusion. What is surprising for an analyst is how to understand the implication of having a new institution with the same objectives without undergoing deep changes following the NIS innovation diffusion tool adoption, experimentation and diffusion.

One explanation of the creation of the MRSI is the exclusion of the national team at FRSIT which was involved in the learning processes for the transfer of the NIS policy tool in Burkina Faso. Having substantial knowledge of the NIS concept, the members of this national team were mainly those who would have had policy proposals based on the NIS policy tool. As attested by a key official: "The ministry was created under the FRSIT activities. It is the different activities of FRSIT which have led to the creation of the ministry to do things because I have worked for that and I have been completely excluded. Now they've put their people there who do not have any knowledge on the matter" (Interview#28).

During the process of transfer, experimentation and diffusion, and considering the other actors they brought into the diffusion process of the NIS policy tool, the national team did not at any time discuss the suitability of the NIS policy tool for pursuing development goals in Burkina Faso as laid down as a justification for the FRSIT/IDRC's project. This recalls the observation of one interviewee regarding the attitudes of people engaged in projects in general in Burkina Faso:

> We avoid criticising projects [development projects in general], I have seen this with the World Bank, at the beginning I was making some contribution by criticising some aspects of the project, I have been Excluded, I was not invited for the meetings anymore, and the representative of the World Bank himself said to me that they are not here for criticism, they are here to build. I said we can criticize while building […] so the director [name] of our research institute was worried that I can compromise the project so I was removed. Well for your information, I think I got a bad behaviour [Laugh]. I don't like people who exclusively look for their own interest (Interview #25).

The replacement of the national team at FRSIT level with new people, (who did not take part in the NIS policy adoption processes) to lead the new MRSI is perceptible from the policy documents design which set the frame for its action. When one reads these policy documents[32] which are[33] it is hard to reconstruct a *complete* framework which reflects the underlying assumptions of the NIS framework. One can identify key words such as 'innovation', 'national research and innovation systems', 'science and innovation policy', 'intellectual property rights', etc. What is clear from the NIS diffusion tool in these policy documents is the idea of a system. This is consistent with what is found in other countries such as Hong Kong (Sharif, 2009); Canada and Quebec, (Cambrosio, Limoges and Pronovost 1990) and Albert and Laberge 2007), Uganda, (Ecuru et al., 2012); that is to say that the interpretive flexibility of the NIS

32Documents on the National Policies for Scientific and Technological Research (PNRST)

33 MRSI. (2012). Politique Nationale pour la Recherche Scientifique et Technique (PNRST) 2013-2025

MRSI (2011) Ibid.

MRSI (2013-14) Ibid.

allows for different usages according to the content that users give it. In other words, by retaining the idea of a system, the shift to other interactive approaches becomes easier.

As said earlier in Chapter 4, the key actors who took over the MRSI for the implementation of the NIS were already working on the competing Multi-Actor Platform approach to innovation. Moreover, the new ministry could count on external funding from the World Bank and others organisations that were sympathetic to such a framework. While the funding from the IDRC for the transfer and implementation of the NIS ended in 2011, in contrast, the INERA, the agricultural institution where the Multi-Actor Platform was implemented is regularly well funded although from external funders. However, the overall frame reflects the NIS concept because:

> The ministry [MRSI] has been created exactly to do [that]. For me, it is really an impression that people wanted to give but in reality there were not really many things, there weren't any. It is true that the ministry is a kind of result of such a project on the innovation systems, but it did not really create a framework to facilitate in ways an innovation system in general in Burkina Faso (Interview #4).

As the above analysis shows, the lack of knowledge of the NIS concept by the new actors in the ministry was an important factor in shaping the NIS policy tool adoption. In other words, the IDRC representative recognises that "the actors did not really understand fully the idea behind the NIS that needed to be promoted as a diffusion tool, so they were not able to conduct things to a good end […]" (Interview #47). In other words, this means that the NIS did not play any further role in policy apart from some rhetorical references. In addition, the dependence of the State on external funding for the implementation of its development policy constituted an obstacle, particularly when a new policy was adopted not for its relevance in advancing the welfare of the majority of the population but for the financial benefit it will give to the central institutions of the State. As an interviewee underlined:

> Unfortunately, we do not have any policy. It is what I call 'the policy of the projects'. That is to say, we are just waiting for the projects [development projects in general] and then we make an idea of [estimate] the money which is involved […]. We do not contribute to write the project. This is disappointing. If you do not participate to the writing up of the project you cannot interiorise, internalise and integrate it. You are just told to do activities and evaluate the amount of money you will receive by doing this and that. At the end you make a report showing that such activity was a success at 80% or 70% even if it was a failure. So, there is no target at all from us local actors, there is very few people who got a target for our bloody country! For me, everything starts from here [having a target]. If you don't have ambition for your country everything at the starting point is falsified. The consequences are enormous: first, we [referring to national local people] accept [agree to take part in implementing] all projects [talking about development project general] as far as there is money. It is like that. Even if it is the Mafia behind it, we do not care, if it can bring money. So we do not look at the project or even participate to its writing up to at least write down our vision. We think that if we do that, the funding body will refuse to fund. So, this is it. The second thing which is linked to the first is that all projects are always seen as positive with good outcomes at the end. It never fails, even if it fails. Financial bodies like to hear that it was a success, because when you say they have funded a project which had important results, they [financial bodies] will show it up everywhere […] (Interview #43)

The interviewee is discussing here about development projects in general and the way local people always happily get involve in their implementation for the purpose of extra cash than their successful implementation.

"It never fails, even if it fails" from above quotation is a key observation, because it brings into serious question the connection between the changes at organisation and policy levels and the outcomes which those changes were supposed to promote.

There is another example of a mismatch between intention and outcome. I argue that the most significant factor which contributed to the shaping of the NIS policy tool adopted in Burkina Faso can be found in the conflicting relationship between research and higher education professional corporations in the context of a weak state. Indeed, actors from both sides acknowledge the long lasting conflict between CNRST and the Universities.

It can be seen that the process for integrating higher education and research was stopped in 1982, which encouraged rather that mitigated the continuing conflict between the parties. What had just been a teaching institute in 1965 became, in 1982, the University of Ouagadougou. Such a centre, with the exception of the expatriate teachers, was staffed by secondary school teachers. Until 1974, the current University of Ouagadougou trained secondary school teachers. After 1982, the University teaching staff were from CVRS. From 1982, a plan was made to differentiate researchers and teaching researchers under a proposal by a French Ministry official who previously worked with the CNRST in France[34]. Since then teaching researchers and researchers were divided into two categories, and the former (teaching researchers) have occupied leading positions in an increasing number of universities

[34] The full paragraph data are from a debate on the creation of the MRSI just after its creation on SYNADEC "A quel ministère appartiennent désormais enseignants-chercheurs?" 28/01/2011 between Magloire, staff from the University of Ouagadougou and Guissou Basile from CNRST (the National Research Centre)

and also research structures at the expense of the later (researchers) who were low both in numbers and expertise. This situation created some tension between University and CNRST staff, which was stated clearly here by one of my interviewees:

> There is a conflict between the two [University and CNRST] only because for [a] long [time], some positions at the CNRST, such as director of institute, was a nomination. It then happens that people from the University sometimes occupy these positions at CNRST. For example, [name someone] was the director of INERA. However, at the University, they wouldn't allow a researcher from CNRST to occupy a leading position. So now, the researchers also said no, only researchers within CNRST with a certain position can apply for these positions. It will no longer be a nomination. It is like that everyone stay in his domain (Interview#52).

In addition to this, many of the researchers at CNRST were not allowed to integrate with the University at the end of their studies. It is clear that going to the CNRST was not their first choice. They were therefore frustrated from the beginning for being refused as teaching researchers. The frustration of these researchers is well documented by (Omobowale et al. 2013).

However, before 2000, the conditions were not favourable for complete separation of the CNRST and the public Universities. Firstly, because different departments at CNRST were still led by teaching researchers; secondly, at the political level, there was no particular interest in the higher education with the adoption of the Structural Adjustment Programme (SAP). Therefore, complete separation was not possible until

2000 onwards, with its increase in high level researchers at CNRST and the interest of funding bodies in R&D.

The willingness to be autonomous started to grow then because of the favourable conditions which were being put in place. The result was the creation of the MRSI in early 2011. The first two ministers were both from the CNRST institute which remained in control. In addition, all department leaders underwent an internal selection process at institutional level prior to their official nomination.

> You can see, it is now a competition to become head of department. You have to put your application in and then meet a panel to present your working programme and defend it. Then based on your academic position and your application, the choice is made by the Director of CNRST and the other committee members […] (interview#58).

The process clearly excluded University teaching researchers. As a result of that some initiatives, such as the NIS as an innovation diffusion tool, initiated by teaching researchers [35] from the University who still occupied a leading role in an institute at the CNRST, were left *'hanging'*. The diffusion tool, initiated by the FRSIT director, who was from University, had not been widely diffused at policy level as he and his team had been forced to leave this to others who lacked understanding on the new tool to diffusion (NIS concept). From an analytical perspective, it is clear that the end of

[35] Refers to scholars working at university, those working at research centers who are doing more research than teaching are called researchers. Given that the FRSIT was led by a teaching researcher, they were those who initially work with the IDRC for the NIS diffusion tool adoption in Burkina Faso

the project on the NIS coincided with the creation of the MRSI in 2011 and the eviction of the director[36], as the following statement shows:

> They then chose to create a new Ministry for themselves. As you can see, they have pushed me aside and put [in] their people. FRSIT has fallen down […]. Until now they haven't done anything. [name] and the others at the ministry haven't done anything at all. What they've done is that they have dug a big ditch between the University and the CNRST (Interview #58).

As with his colleague[37], the former Permanent Secretary of FRSIT would not support the creation of a new ministry.

The shaping of the NIS adoption at policy level is the result of complex factors. One of them is linked to a lack of understanding of the actors who took over the lead through the MRSI. Another aspect is financial, which is more or less the case for the whole country which was, for a long time, under an authoritarian regime strongly dependent on external financial support from international institutions. However, the key factor which hindered the full institutionalisation of the NIS as a policy tool for innovation diffusion in Burkina Faso is the long standing conflict with researchers who nevertheless remained key actors in the elaboration and implementation of development policies. These researchers are those the policy makers rely on for policy proposals. This is highlighted here by a senior official:

[36] I am not evaluating the director's expertise, (who was from university), or evaluating the FRSIT itself, instead I am evaluating the institutionalisation of the NIS framework that is mentioned.

[37] The full Paragraph is taken from a debate on the creation of the MRSI just after its creation on SYNADEC "A quel ministère appartiennent désormais leenseignants-chercheurs?" 28/01/2011 between Magloire, some from the University and Guissou Basile from CNRST

> Well, what is the State? Who is the State? The State is the researchers and the technical agents who diffuse, it is in fact this. This is the reflection. The minister will ask its experts to make him some proposals and it is based on this that we focus. In fact, I said, we do not work, we do not think. Even when he [minister] asks his agents to write a proposal, they don't put the required effort to do it […] so in fact, the State is these technicians. (Interview #30).

The consequence is that partisan interests undermined public interest objectives, as is apparent in this statement:

> What I'm saying here is my point of view. But what I have noticed since I was a researcher is that whatever it is, a research project or a development project, the first idea of the national actors is material aspects, that is to say the 4x4 cars. That is what I call material, oil vouchers, travels, honoraria; this is the first idea that people have. One time I participated to a project on […] and we wanted to make people understand that we can contribute, later I heard they have given it to other people […] you see. So, the first problem that we have is the lack of, I do not know how to qualify it, lack of initiative, the country's development is not the first priority we usually think of. (Interview #32).

This underlies another disjunction between the intentions in relation to the adoption of NIS as an innovation diffusion tool and the problems of implementation, associated with the failure to make a successful move from the niche level to the regime level. This included weaknesses in relation to the exploitation of existing knowledge and expertise within both FRSIT, research and university settings, and the lack of commitment to the implementation of and evaluation of the implementation of the new policy tool.

5.4. Conclusion

The rise of the knowledge centred development policy has put pressure on the existing innovation diffusion tool (training and visit), thus creating windows of opportunities for a search of a more interactive approach to diffuse innovation. Is was from this perspective that the NIS as an innovation diffusion tool was thought to be most suitable for knowledge diffusion in Burkina Faso. In this context, after the unsuccessful implementation of different innovation diffusion approaches, national actors from the National Forum for Scientific and Technological Innovation (FRSIT) in Burkina Faso were informed about the existence of the NIS policy tool for innovation diffusion for socio-economic development. They were made aware of this innovative approach by the IDRC, a Canadian research and development organization which has an office in Africa. The national actors saw in this innovative policy tool an alternative for the design and implementation of innovation in the context of knowledge-cent red development policy. This chapter has therefore investigated the process through which the NIS as a diffusion tool was adopted. In so doing, the Chapter has in its first section depicted the Forum of Scientific Research and Technological Innovation (FRSIT) as a niche within which the NIS as an innovation diffusion tool was transferred and experimented on, by describing its context of creation, its missions and its organisational set up for innovation management. The second section explained the process of stabilisation of the NIS diffusion tool at niche level, by highlighting the learning processes, experimentation and network building involved in this. Such learning processes consisted of undertaking training sessions, meetings, symposiums, workshops and conferences in order to experiment with and build up the network of relevant actors who were interested in adopting the technology. The last section explored the institutionalisation of the NIS diffusion tool through an analysis of its adoption and diffusion processes as manifested in its policy design. The full implementation of the NIS did not happen at policy level. As the findings have shown, one key aspect which hindered such institutionalisation was the fact that conflicts between researchers from CNRST and Universities that resulted in institutional changes and the eviction of the NIS concept promoters. When considering the content of the National Science and Innovation policy, there is little evidence to support the claim that the NIS tool has been used by policy makers in the design of policies. Although the creation of the Ministry of Scientific Research and Innovation on the 16th of January 2011 is a result of significant changes at institutional level following the NIS adoption, the text of the ministry policy documents indicate that the NIS framework has not informed the policy design. As a result of the exclusion of the national team at FRSIT which had been involved in the learning processes for the transfer of the NIS policy tool to Burkina Faso, who would have had policy proposals based on the NIS framework, the NIS had failed to be adopted as a policy tool. Indeed, the new actors who took over the lead of the Ministry wanted to promote another well-funded approach known as the Innovation Platform that they were implementing even before they joined the ministry. This conflict is a continuation of a deeper long conflict between university and research centre scholars. It was an important factor in shaping the NIS policy tool adoption for innovation diffusion in Burkina Faso. Consequently, the NIS policy tool for innovation diffusion in Burkina Faso was not diffused as it should have been as individual interests have taken over the country's socio-economic development.

In the last part of the thesis, I'm going to explore the Sectoral Innovation Systems (SIS) for cotton from the perspective of the operation of a pre-existing National

Innovation Systems, and the impact of the introduction of the Bt cotton innovation. It will examine how these two innovation projects, the NIS and Bt cotton, played out, given the socio-technical and organisational systems in place in Burkina Faso at the time.

Part III

The National Innovation Systems and Innovation Diffusion in Cotton Sector

Chapter 6: Transformation of the Cotton Regime in Burkina Faso: from Traditional to Bt cotton ST-Systems

6.1. Introduction

As stated in Chapter 1, this thesis investigates the NIS inspired policy tool and the Bt cotton innovation system. I earlier examined the introduction, development and implementation of the NIS as a policy tool for innovation diffusion in Burkina Faso in Chapter 5. There I investigated the transfer and implementation of the NIS policy tool from the niche (FRSIT) level and its subsequent diffusion at policy level through its institutionalisation and changes in innovation policy strategies. Now, in Chapter 6 and 7, I shall investigate the diffusion of the NIS from the same niche level and its diffusion at operational level through the Bt cotton case. Methodologically, the study of the transition to the NIS as a policy tool cannot be limited at strategic level to how it shapes policy options. It also needs to take into account the appropriation of such a policy tool at operational level. From this perspective, it was therefore relevant, regardless of the state of the diffusion of the NIS policy tool at strategic policy level, to study its diffusion at operational level in the agricultural sector. These two levels share the same niche (FRSIT) that is the place within which the NIS policy tool was tried out and diffused, given that the policy strategic and operational levels diffusion can happen either theoretically successively or simultaneously.

It is this methodological requirement that justified the study of the NIS at both strategic (Chapter 5) and operational (Chapter 7) levels along the policy continuum.

This consisted in laying down the background of the different innovation systems before the arrival of the Bt cotton in the 2000s which will be examined in this Chapter. It will chronicle the changes in the production of cotton in Burkina Faso, beginning with the pre-colonial period before the 1900s and ending in 2003 with the introduction of Bt cotton. In each successive socio-technical system, it will be shown that the type of cotton grown, as well as the organisation and the purposes of production have changed over time to reflect the political and social context, which together shaped the quantity of cotton produced. Each historical period corresponds to a specific combination of these factors. Each specific combination can be referred to as a 'socio-technical system' or regime in Geels' (2004) terms. Then, in next Chapter 7, the Bt cotton innovation system in particular is going to be investigated.

The present chapter is organised into three sections. Each section corresponds to a historical socio-technical regime. The first covers the period from pre-colonial to the colonial regime (1897-1960); the second is associated with the first three decades of post-colonial government in Burkina Faso (1960-1991); the third section covers the decade of the liberalisation regime (1991-2003).

6.2. The Socio-Technical System of Indigenous Cotton Production in Pre-colonial Burkina Faso

In this section, the historical context in which Bt cotton was rooted is presented, focussing on the key actors, their roles and objectives in relation to cotton growth during the pre-colonial era. During this period, cotton cultivation was essentially subsistence agriculture, and this was reflected in the type of cotton grown, the actors involved, its organisation, and the purposes for its production. The pre-colonial models of social development were more restricted and involved less marketing than later models. Throughout the period, it could be said that because cotton was an essential crop for people's survival, its wider economic assets were disregarded (Kaminski, 2009).

6.2.1. The Types of Cotton Grown in Pre-colonial Burkina Faso

It is crucial to outline the species of cotton grown during the pre-colonial era in Burkina Faso, in order to set the background for the genetically modified Bt cotton that was introduced in 2003. During that period, three different cotton species were cultivated, which had been used for many generations, (Gray, 2005; 2008). The three varieties, known as 'Gossypium arboretum', 'Gossypium hirsutum', and 'Gossypium barbadense' (Schwartz, 1993), did not originate locally, but had been imported. It seems that cotton appeared between the 10th and 13th centuries in Africa and has played a key role in the economic development of the continent, and in particular of West Africa (Schwartz, 1993; CNRST, 2007). Of the above three varieties grown across West Africa, the first variety, 'Gossypium arboretum', originated from the Eastern part of Africa and India (Schwartz, 1995: 208), and was grown in ancient times. Although we can date when cotton was introduced to Africa, it is very difficult to ascertain, from either literature or individual sources, the exact period or date when 'Gossypium arboretum' was first introduced to Burkina Faso.

By contrast, the other two cotton varieties, 'Gossypium hirsutum' and 'Gossypium barbadense', originated from the America and were introduced to Burkina Faso in the 18th century through trans-Atlantic trade (Schwartz, 1995:208). Until 1897, these three varieties of cotton were grown in the country without any alternatives, changes or improvements (Schwartz, 1993). The value of the crops in existing markets was of no particular consideration for cotton growers since its growth was aimed solely at meeting family subsistence. Indigenous people at that time focussed their efforts on their immediate needs, rather than seeing cotton as a tradable good (Schwartz, 1997; 1999). It follows that there was no significant need to improve the above three varieties in the pre-colonial era because farmers and consumers cultivated these cotton species mainly for their own consumption, with every part of the plant being used for a variety of purposes.

6.2.2. Cotton Cultivation Techniques

The regular cultivation of cotton by farmers, combined with organisational factors, reflects the subsistence farming system of the period. Within that context, two dimensions are essential to consider: the technical dimension, covering tools and methods; and the indigenous knowledge of subsistence farming. During the pre-colonial period cotton was considered a subsidiary crop behind the other main subsistence crops, which were directly used for nutritional consumption (CNRST, 2007) and its growing status reflected this. It was grown on a very small scale, generally by women, who grew cotton in fields alongside 'sauce' condiments, such as peppers and okra and other modern-day cash crops such as tobacco often within millet or sorghum farms. "Production was low and primarily used at home, spun into strips of cotton thread that were then made into clothing and blankets" (Gray, 2008:68). Nevertheless, it was an important local crop in pre-colonial Burkina Faso Gray (2008).

In Burkina Faso, as in many African countries, the agricultural sector in general, and cotton in particular, relies on the rainy season which lasts between five and seven months. The growing techniques were as follows: seeds from some of the crops, including cotton, were kept aside after harvesting for planting the next rainy season. This cycle of crop saving was repeated every year (Schwartz, 1991; 1993; Gray, 1999; 2005; 2008; Roberts, 1995). Biological fertilization by the slash-and-burn method was used to enrich the soil, usually during the dry season. Cotton growth techniques were similar to those of other crops and not given any particular attention (Bassett, 2001; 2008; Gray, 2008). The techniques were traditional and the tools were exclusively simple, handmade and for manual use. (Bohannan, 1959; 1968). For instance, machetes, knives, and hoes were made by local black smiths from iron bars or scrap metal and used for cultivation in the agricultural sector as a whole in many African countries (Bohannan, 1959; 1968). From sowing until the harvest, all the processes were manual, involving mainly human strength as the significant labour force. As in many parts of Africa, the hoe handle was made from a green forked branch by the man who owned it, or it could be bought from his kinsmen or friends (Bohannan, 1959). A man also had a duty to make these tools for his wives and mother (Ibid.).

These factors had a significant impact on the rate of indigenous cotton production, which was between 50 to 150kg/ha (Schwartz, 1995). However, this seemingly low productivity was enough to fulfil the family's needs, because in the domestic economy, quantity was not the first objective (Schwartz, 1997). What was imperative for farmers in general was that their cotton production would cover the family's needs in terms of clothing and food. The longstanding nature of the above techniques and tools used to produce cotton in pre-colonial times reveals a settled ST-System in terms of the labour distribution/division, and a lack of pressures for change (Goreux and Macrae, 2003; Gergely, 2004; Gray, 2008; Bassett, 2008).

6.2.3. Work Distribution in Cotton Growth

According to oral tradition, cotton cultivation had a vital place in the household. Cotton processing such as spinning and weaving were shared between family members according to their sex and age. Women (mainly old but also youngsters learning) were assigned to spinning. In the Mossi tribe, for example, all women and girls knew how to spin (Schwartz, 1993; CNRST, 2007). Weaving was mainly men's work, particularly those from a griot (storyteller of genealogies and oral traditions), or blacksmith culture. In this respect, ethnic and social groups shared the labour involved in cotton production and processing. By this division of labour in traditional Burkina Faso, all the processing, ginning, spinning and weaving was done locally, usually within the same family. Labour was gender divided and shared between men and women (Schwartz, 1993). Division of work according to gender is part of African and many other cultures. According to Kaminski et al. (2009), cotton was cultivated not only by the Mossi but also by other ethnic groups, namely the Senoufo and the Bwa, and processing was done by the Marka ethnic group.

With respect to work distribution in cotton cultivation during the traditional pre-colonial era in Burkina Faso, it appears that this early specialisation of the duties of different actors involved in the process sometimes occurred within the same family, and that the family was the central point of cotton production and processing (Roberts, 1995; Gray, 2002; Gray and Kevane, 2001). However, it is also the case that, in the absence of industries, weaving was often done by specific castes: griots, or blacksmiths, according to the patriarchal and ethnic division of labour in a traditional economy. The distribution of work involved in cotton growing could therefore be done along several lines, including gender, ethnic group, caste and age. It is important to note that the knowledge supporting all these processes, from the organisation of work to the methods and tools used, was traditional and rooted in Burkina Faso's social context at that time (Gray, 2008). It can therefore be concluded that indigenous cotton growth was bound by social, cultural and economic beliefs, which influenced the restricted cotton usage of that time. In other words, the pre-colonial ST-System was characterised by a combination of indigenous knowledge, locally-produced tools, family as well as caste-based labour and cultural traditions.

6.2.4. Objectives and Uses of Cotton Cultivation

In the pre-colonial era, cotton was grown to meet a range of family needs: domestic, cultural and economic. Firstly, in Burkina Faso, domestic needs had two main dimensions, namely food supply and clothing. Food was made from cotton grain and dishes such as sauce, soup, and couscous were included in the family's daily diet. In addition, cotton fibres were made into clothing for family members (Gray, 2008).

Cotton was specifically used in wedding packs for young women who gave their spun cotton to the weaver to make their wedding clothes (Schwartz, 1993, 1995, 1997)

Secondly, cotton or its grains were imperative for specific ceremonies and cultural events, including those for health, wealth and luck and the ceremony concerned with weaving cloth to cover or dress the dead (Schwartz, 1991; Isaacman and Roberts, 1995; Gray, 2008). A special soup with cotton grain was given to groups of children in the village or compound at dinner time to release the sense of innocence and a wealthy spirit on the family according to the oral tradition (Gray, 2008; Bassett, 2008). This aspect of ritual or magic was very important and involved in ceremonies around the cultivation process for crops such as cotton. It is raised in many studies relating to the use of magic in social organisation. Malinowski (1965) considers it a key element, and notes its specific form in the African context. He asserts that:

> No human beings, at whatever stage of culture, completely eliminate spiritual preoccupations from their economic concerns whether we pray for our daily bread or for adequate rainfall; whether the divine kings of Africa exercise their powers for fertility or moisture. (Malinowski, 1965: XX).

Finally, economic needs were met through two types of markets: the local market and neighbourhood exchanges, another type of market activity which was more open than the local market (Bohannan, 1968). In the local market, buyers and sellers exchanged products for cowries. Sellers sold both raw cotton and woven cloth within the local market. The exchange was based on the traditional economic principle where society was not based on the market and would not perish if the market crashed. Monetisation was not well developed in Burkina Faso at that time. In Bohannan’s words:

> In the subsistence economies of Western Africa, the principle of reciprocity or of redistribution is likely to be dominant and the principle of market peripheral: the market exists and products go into it, but it is like gift-giving in the West: it could disappear without chaotic results. (Bohannan, 1968: 203)

The market in this traditional context does not greatly affect people's lives. In Burkina Faso, it was in this type of local market that cotton was traded. Traders (mostly women) sold their spun cotton or cotton brute (hard cotton) and men offered woven cloth for sale. However, the trade was always done with any surplus cotton, once traditional needs had been met. It should be mentioned here that this method of trade was significant in the context of the period (Schwartz, 1991; Roberts, 1995; Bassett, 2001). With respect to exchanges with neighbouring countries, it is also worth noting that trade was more open than in the local market and cotton was exchanged for products such as kola nut and salt which could not be found locally (Labouret, 1928; Schwartz, 1993). The transaction consisted in getting the equivalent value of other products for the cotton traded Bohannan (1968). If there was no equivalence, bargaining was employed to agree on the products' value. The way both markets were organised in Burkina Faso "works precisely as it does anywhere else, the difference is that it affects the way of life of the people very much less" (Bohannan, 1968: 203).

In these pre-colonial times, cotton farmers interacted with neighbouring regions to exchange their surplus produce for something equivalent, and sold part of their produce (cotton brute or processed derivatives) on the local market (Labouret, 1928).

Table 11: Summary of the traditional cotton growth system in pre-colonial Burkina Faso

Actors in indigenous cotton growth	**Work organisation**	**Variety of cotton grown**	**Tools and tool makers**	**Cotton usages**
Cotton farmers Blacksmiths, Spinners, Weavers	Men weaving and women spinning, both farming	Gossypium arboretum, Gossypium hirsutum and Gossypium barbadense	Griots (story tellers and also tools' makers) blacksmith, (tools makers: knives, pick axe)	Family, cultural and commercial in the local market and neighbourhood

Source: Processed by author

To sum up, the role and place of cotton is constructed in accordance with the way its actors interacted during the pre-colonial period. The ST-System of indigenous cotton was mainly a familial network of actors. As a result, the interactions between actors around indigenous cotton (the artefact) were limited in terms of diversity but stable. Both users and producers were within the same family and shared cultural similarities. In addition to the traditional way of growing cotton, both organisation and processing were distributed within the same family or kinship group. The system tended to be closed and less commercialised than later systems with few actors involved. Producers and users of the artefact were both in the family where growing, spinning and weaving were done.

Furthermore, the use of indigenous cotton centred mainly on family consumption, with the result that the type of cotton, the organisation and its use were controlled by family needs. This suggests that the ST-System of indigenous cotton was small-scale. This early regime was rooted in the way cotton growth was defined at that time, based on a subsistence economy within a small geographical area. The two main bodies here are the human actors (family) and the artefact (indigenous cotton). The interaction and dynamism of these two bodies form the ST-system of that historical epoch. The traditional regime which constituted this ST-System would later shape the interaction of farmers with officials during the regime change which followed. This regime forms the basis of the following ST-System of cotton, which will transform it to fit its requirements.

6.3. The Socio-Technical System of Conventional Cotton in Colonial Burkina Faso

Colonisation was a complex set of processes and made a deep impact on African society's structures and foundations. This general statement applies directly in the specific case of Burkina Faso's traditional cotton growth structures. It is therefore necessary to shed light on the story and in particular the objectives of French colonial power in indigenous Burkina Faso. In West Africa, colonisation started in the early twentieth century and entered Burkina Faso in the 1900s (Ki-Zerbo, 1978; Crowder, 1968). Colonisation radically transformed Africans' political, economic and social patterns (Konate, 2011). In the French colonies of West Africa, there was a reorganisation of the flow of goods and services in the directions required by the externally-oriented nature of the economy-based objective (Amin, 1972). The French held most of what would come to be their colonial territory in West Africa (including present day Senegal, Mali, Burkina Faso, Benin, Guinea, Ivory Coast and Niger) (Baffes, 2007). West African people at this time became subjects, and not citizens, in their own territories. The colonial system was aimed at destabilising and replacing the traditional African social context, cultural values, political aspects and most importantly its market design and aims. In this section these objectives of French colonial power in West Africa are described, and their impact on the cotton growing system are analysed.

6.3.1. Colonial Penetration

The French colonial encounter in West Africa was driven by commercial interests and, perhaps to a lesser degree, some sense of a 'civilising' mission (Hargreaves, 1979). The political administration and economic interests were fairly uniform throughout the colonial period. Little was done to improve the lives of West Africans, although attempts were made to provide minimal health and educational services. Socio-cultural, political and more importantly economic interests were the motives of colonisation (Ki-Zerbo, 1978). The first objective was the social and cultural assimilation of colonial penetration in Francophone West Africa. These social and cultural matters were part of the colonisers' focus (Ki-Zerbo, 1978; Chafer, 2002; Ouedraogo, 2003; Sissao, 2003), and were mainly fulfilled through education and religion. These two strategies of colonisation were the means by which France spread its culture and civilisation throughout its colonies. The old African civilisation would be transformed. When the original federation of the French West African colonies was achieved there was no outright statement of the programme for assimilation, nevertheless, education and religion were two useful mechanisms for the introduction and implementation of colonial cultural values (Ki-Zerbo, 2003). Prevailing western approaches to education and religion replaced traditional ones. The colonial educational system and its religion significantly involved alienation and domination, and was used to support the full exploitation and fundamental control of its colonies by France.

The second objective was political control. France, in colonising West Africa, aimed to take control of African territory (Ki-Zerbo, 1978). France was determined to make 'French West Africa' its own territory where it would be in charge of administration and decision-making (Ouedraogo, 2003; Sissao, 2003). To achieve this, France installed a centralised administration in its new territories, a system of direct rule (Ki-Zerbo, 1978). Traditional chiefs lost their power to the control of the French (Skinner, 1989). Local traditional governance systems became incapacitated. In the interior of French West Africa, young people were captured and sent as soldiers to fight on behalf of their masters and mother country (France) (ibid.), as was the case during the Second World War. The control and administration of West Africa by colonials was generally harsh, according to Crowder, (1968). By removing traditional chiefs this centralised administration aimed to promote the building of a modern State through national governance.

6.3.2. Colonisation and Economic Concerns

The main objective of colonisation centred on economic concerns. France wanted to extend its market and gain huge profits from its colonies (Schwartz, 1993). European powers were short of natural resources for their industrial progress, so it became necessary to find a supplier and cheap labour market (Labouret, 1928, Schwartz, 1993; Gray, 2008; Bassett, 2008). The French attempted to increase their economic foothold, utilising forced labour and imprisonment in order to maintain and expand their interests. The French administration sought to increase productivity in its colonies and extract valuable resources from them (Schwartz, 1993). It fostered the production of groundnut and cotton where appropriate conditions were present, and imposed taxation as a means of inducing participation in the cash economy. Where crops could not be grown, the administration encouraged internal migration to wage-earning areas.

In 1902, the America was producing almost three-quarters of the world's cotton (Schwartz, 1993), which made it powerful and influential in the cotton sector so that it dominated the world cotton market. This was to Europe's detriment since most European countries were dependent on America cotton growers for their textiles (ibid.). This domination by America was one of the reasons why Great Britain, Germany, and France turned to African countries where cotton had been traditionally cultivated for many centuries and where the climate seemed to be appropriate for cotton growth (Labouret, 1928). In the 1920s cotton became a coercive tool in the French Upper Volta colony when its cultivation became compulsory, even though farmers often circumvented the "forced corvée" through out-migration, and by selling their cotton on the local parallel market or by exporting it to Ghana (the Gold Coast) (Schwartz, 1993; Goreux and Macrae, 2003; Gergely, 2004). Schwartz (1997) believes that the cotton crisis in Europe was the main pretext and opportunity for cotton to be developed in Africa for the world market. Africa was to become the biggest, cheapest and most competitive main supplier of cotton to European industries (Labouret, 1928; Bassett, 2001). The colonial regime thus focused on the need to expand and enlarge land areas for cotton growth to secure France's supply line and to create profits.

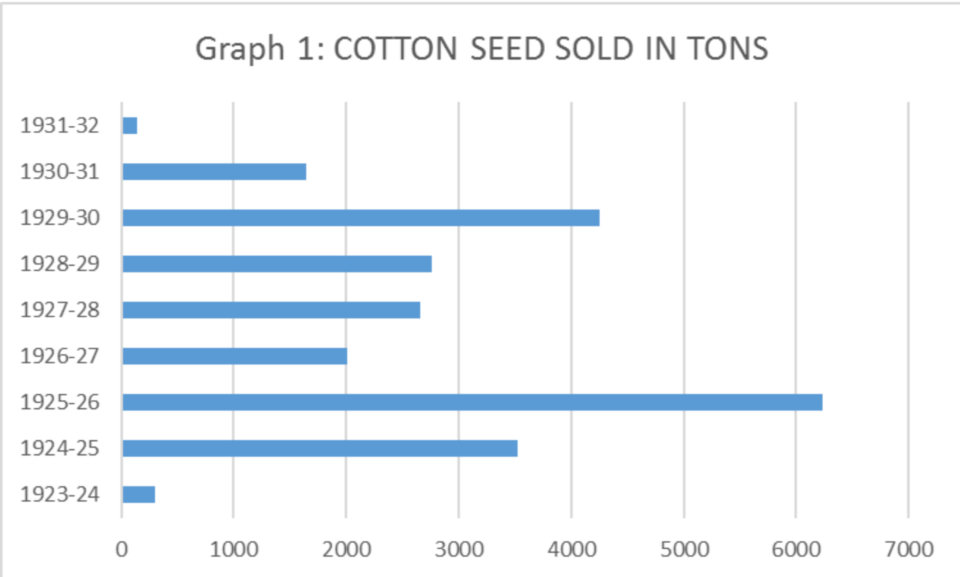
6.3.3. Colonisation and Cotton Growth Redefinition

These cultural, political and economic objectives, resulted in changes regarding the aim of cotton production in the case of Burkina Faso. The type of cotton grown, the organisation and the purposes of production were all deeply affected by the new French colonial aims. The colonial system therefore produced another social, cultural, and political structure, in other words, a new S-T System, as a result of which indigenous cotton varieties, organisations and use would change significantly.

6.3.4. The Economic Focus in Cotton Cultivation

The colonial market economy created new conditions for cotton. Cultivation was different because of greater economic demand compared with the traditional focus on subsistence local consumption. The three varieties grown during the pre-colonial period, ‘Gossypium arboretum’, ‘Gossypium hirsutum’, and ‘Gossypium barbadense’ had been cultivated for several generations, without any improvement in the quality of the seed. French economic ambitions could not be realised through these traditional varieties so there was a need for alternatives or improvements to existing varieties in order to increase productivity and quality to meet new market needs including the development of the French textile industry. Therefore, cotton trials using basic research started in the early 1920s (Schwartz, 1991; CNRST, 2007). For instance, 1923 saw the creation of Saria (a village in Burkina Faso) experimental farm (Bantenga, 2003). The three traditional varieties were subjected to trials and improved varieties were implemented by technical agents trained at the experimental farm in Saria from 1924 and gave a real boost to cotton growth (Schwartz, 1995; Zoungrana, 2003, Bantengan, 2003). As it appears clearly in graph 1, cotton growth reaches its peak between 1925 and 1926. Sold cotton went up to 6,238 tons and did not go below

1,500 tons until 1931-32 when it dropped to 142 tons. This fall in the cotton trade is explained by the fact that Upper Volta (now Burkina Faso) was split and shared between its neighbouring French colonies at that time. Because of this, there are missing data concerning cotton growth between the period 1931 and 1950 (Schwartz, 1993).



Source: Processed by author from:

Schwartz A (1991) ‘L’exploitation agricole de l’air cotonière Burkinabe : Caractéristiques sociologiques, Démographiques, Economiques’, Document de Travail, ORSTOM, Ouagadougou.

Schwartz, A. (1993). *Brève histoire de la culture du coton au Burkina Faso*.ORSTOM: France

6.3.5. Modernisation of the Cotton Sector

After colonisation the cotton sector was beginning to be modernised and commercialised. Frederic-Charles Edouard Alexandre Hesling, an appointed lieutenant governor for Upper Volta, promoted cotton growth from the early 1920s (Schwartz, 1993) and the exponential growth in the production of cotton provided obvious satisfaction for the French colonizers (Schwartz, 1995; Bantenga, 2003). This was also the beginning of agricultural research in Burkina Faso, a sector which until then had been traditional and archaic in its methods and technology (Bantenga, 2003). New actors appeared under the auspices of the colonial authority: the Colonial Cotton Association (ACC), born in the early 1900s, and research institutions such as the French Institute in West Africa (IFAN), created in 1938 (Kaminski et al, 2009; Vitale et al. 2011). With the involvement of these new colonial actors, organisational systems in the subsistence economy such as traditional gender labour division and the techniques and tools employed in farming underwent significant changes to satisfy colonial market needs (Pare, 2001; Schwartz, 2003; Bantenga, 2003; Kutting, 2003). The cotton market economy could not operate at the desired high level of development if cotton was grown as a secondary crop on a small piece of land with simple tools and techniques. There was a need to promote a new organisational system in order to increase productivity and market competitiveness.

Consequently, the division of labour in cotton production during the colonial period became structured outside the family and involved industrial rather than manual processing. The Colonial Cotton Association (ACC) and Cotton Union of France Empire (UCEF) created in 1941 were the leading actors in cotton production (Baffes, 2007; Gray, 2008; AFD, 2008) and later, in 1946, began to focus more on the scientific aspects of cotton growth. The textiles industry (CITEC) was another structure involved in cotton cultivation. This institution bought the hard cotton in order to process and sell it. The French Fibre company (CFDT) specialised in the technical training of cotton growers. All these structures and institutions combined with private institutes were involved in cotton growth and the labour was shared between them. The cheap, hard labour required for growing was supplied exclusively by indigenous people in Burkina Faso who worked under strict supervision on the cotton farms to enable France to fulfil its demands.

This brought about a cotton revolution in 1923 in Burkina Faso and a fundamental restructuring of the growing process for France's commercial and industrial purposes (Schwartz, 1993). For instance, productivity rose to 3,528 tons between 1924 and 1925, whereas it was from 50 to 150kg/ha during pre-colonial time (Schwartz, 1993). Cotton growth became obligatory farming work between 1924 and 1929. Characterised by a huge increase in productivity, cotton growth was no longer the concern of a specific ethnic group, and team work was encouraged within and outside the villages. The old system of labour division according to gender was removed completely. All the local people, whether they were involved voluntarily or not, worked in a team at village level (Schwartz, 1993).

Following these early and spectacular results, productivity began to decline from the 1930s onwards (Schwartz, 1993). This was associated with the intensive and laborious nature of cotton farming under this S-T System, coupled with the unintended consequence of a sharp reduction in the available labour force as indigenous farmers left Burkina Faso, as the next sections explain.

➢ Industrial Process Versus Manual Spinning and Weaving

France undertook industrial spinning and weaving (Goreux and Macrae, 2003), but spinning had been a local activity and now much of this work was taken away from local spinners and weavers. All that was wanted from the farmers was the raw cotton. In this new organisational system, they were only used as a labour force. This new labour distribution was combined with new techniques, tools and methods in order to attain the high-level of productivity required (Schwartz, 1997; 1999).

➢ Shift from Traditional Techniques

Although the traditional techniques and tools (manual farming, hoes, and machetes) continued to be used, the colonial power could not rely on these solely, given the pursuit of large-scale production and huge profits (Goreux and Macrae 2003). Farmers were given new tools and taught advanced methods by technical agents trained at Saria and other structures such as CFDT (Gray, 2005; 2008). They were organised in teams to work on large areas of land, used exclusively for cotton production, in contrast to the small tracts used in pre-colonial society. The colonial authorities' organised internal migration from the villages where cotton was not grown (Gray and Kevane, 2001). The coloniser focused on grouping the rural community into teams. The achievement of communal cotton cultivation was believed to be the most successful method of optimizing cotton productivity in rural Burkina Faso (Schwartz, 2003) and cotton production increased during the colonial period when it became associated with colonial industrialisation (Isaacman and Roberts, 1995). Communal farming started in the 1920s. From the French point of view, the participatory and mutual cooperation and association of farmers would enhance cotton growth and the rural development of indigenous society (Schwartz, 2003). Although communal farming had been believed to increase productivity, it had, in the end, led to a decline in indigenous cotton growth. In addition, this technique of team work meant farms needed carts and domesticated animals to provide labour assistance and improve growing processes (Gray, 1999; 2002; 2008). Furthermore, chemicals and insecticides were introduced to increase productivity both in quantity and quality.

- **The Birth of Research on Cotton**

Another difference in the new S-T System emerged in that productivity was approached as a technological issue, which prompted a search for knowledge about cotton production from the 'hard' sciences and neglected the potential contribution of the social sciences. Research started slowly in the agricultural sector and was done through field trials and basic research. Farmers received training from technical agents (see Chapter 4). Research laboratories emerged and developed slowly in the colonial context. More research was done in the mother countries by their scientists rather than by Africans who were deemed to be insufficiently qualified. In general, this contributed to increasing the yield of the crop (Bantenga, 2003; Konate, 2003; Kaminski et al., 2009)

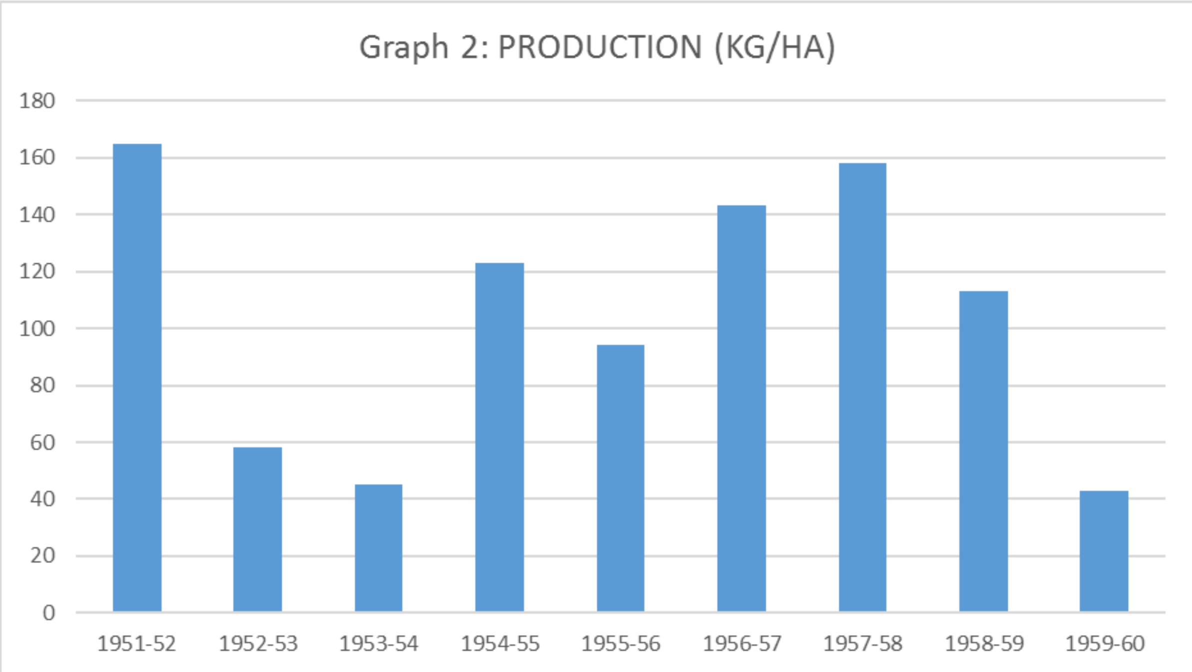
- **Economic Focus Versus Familial Consumption**

With the advent of colonialism, the market became the foundation of the economy and its malfunctioning would adversely affect society. It was what Bohannan called a 'monetized economy' (Bohannan, 1968). Expanding the market was the main policy of the colonial government and there was an exclusive focus on the commercial aspects of usage. African domestic trade was eliminated or reduced to subordinate primary collectors (Amin, 1972). Familial consumption and the cultural usage of cotton slowly disappeared with the extension of the economic usage.

From this point of view, it is fundamental to note that the development of capitalist features in the system was not new to African society, though it took on the process of transforming Africa’s old and traditional capitalistic system to a modern one. The traditional economy based on local markets and neighbourhood exchanges was replaced by a more monetized market with its own taxation system, thereby gradually transforming the market to become the key element in African society. As Cohen argued:

> […]‘Trading areas’ of West Africa and part of East Africa, [was] where the pre-colonial mode of production was distorted and made to serve capitalist needs through peasant production of cheap raw materials exchanged for more expensive consumer goods. (Cohen, 1981: 2).

In this colonial market, buyers and sellers were in a wider network and exchange was for more expensive goods. In Burkina Faso, the colonial cotton trade was controlled by France, which had political, social and cultural power over the country. Gray attested that “French colonial authorities attempted to increase production by forcing peasants to cultivate cotton in village fields. The policy was a complete failure” (Gray 2008: 69). Indeed, the imperialism of the colonial regime resulted in revolts by the local population followed by a massive outward-migration of farmers into Ghana in the early 1930s (Schwartz, 1997, 2003; Sawadogo, 2003; Zoungrana, 2003). Cotton growth declined without strong young farmers, and therefore there was a long period from 1932 until 1947 when the colony faced financial difficulties resulting in the loss of the colony's prestigious position in the cotton industry (Zoungrana, 2003; Bantenga, 2003; Sawadogo, 2003). As shown in graph 2, the cotton production was unstable in the last decade of the colonisation before independence. After the reconstitution of the colony previously split and shared between its neighbourhood colonies, it went up to 165 kg/ha between 1951-52, before declining the following two years to 58 kg/ha then 45 kg/ha. Until independence, cotton production remained low, 160 kg/ha in 1960-61 as in the graph 3.



Source: Processed by author from:

Schwartz, A. (1993). *Brève histoire de la culture du coton au Burkina Faso*.ORSTOM: France.

Schwartz A. (1995) Attitudes to cotton growing in Burkina Faso: Different farmers, different behaviours. In Cattin B.M, Griffon B. and Guillaumont P. (eds) *Economics of agricultural policies in developing countries*, Paris: Revue Française d'Economie.

AfDB, OCDE, PNUD, (2014). African Economic Outlook. Burkina Faso. 2014.

There was a need to rethink the methods used in growing cotton. Farmers reverted to individual farming which replaced the collective model, which led to the disintegration of the colony (then Upper Volta), and its merging with neighbouring colonies like Cote d'Ivoire (Bassett, 2001; Kaminski et al, 2009; Ki-Zerbo, 1978). Thus the story of cotton in West Africa and in Burkina Faso was both an economic and a political one. The success of cotton as an economic crop was short-lived. The colony could not exist without economic independence. This difficulty in growing cotton was one of the reasons that Burkina Faso, (known as Upper Volta at that time) was dismantled in 1932. This shows how much the colony's destiny was linked to cotton growth in a regime described by Ouedraogo (2003) as "the authoritarian, capitalistic and patriarchal rule of colonialism". These new conditions inevitably affected the basis and aims of cotton growth by the native society which was undergoing several radical changes.

Table 12: Summary of the conventional cotton growth system in colonial Burkina Faso

Actors involved in cotton growth	**Work organisation**	**Variety of cotton produced**	**Tools and tool makers**	**Usage of cotton**
Colonial power, Cotton farmers, Blacksmiths, Industries for spinning and weaving. A few Technical agents, Research institute	Men farming, Industries doing the spinning and weaving Research began	Improved Gossypium arboretum, Gossypium hirsutum and Gossypium barbadense	Griots (Story teller and tools maker), blacksmith, (picks, axes, knives, ploughs), few insecticides and fertilizers	Only for commercial purposes (world market) No domestic consumption

Source: processed by author

To conclude, there was a particular shape given to cotton by the interaction of its actors during the colonial period from 1900. The ST-System of improved indigenous cotton, (conventional cotton), was primarily characterised by a large network of actors with different labels and specialisations whose interactions were diverse. Users as well as producers belonged to different specialisations. The family system of ownership disappeared and the colonial power took control of conventional cotton cultivation. This new political regime came with the aim of growing cotton for the market. In addition, the organisation and processing were distributed to industries and researchers outside the family. The new regime was more open and mainly commercialised with more actors' involved and interaction related to their expertise. Cotton growth specifically meant the establishment of team work, research and industries in its growth and transformation. If growing was done by the farmers, weaving and spinning were done by the industries (Goreux and Macrae, 2003; Gergely, 2004).

In terms of producers and users of the artefact (conventional cotton), there was a different set of actors whose interaction animated the ST-System of the colonial period. Furthermore, the usage of conventional cotton was essentially for the market, therefore, the type of cotton, the organisation and the usage of cotton was bounded by market needs, showing the ST-System of conventional cotton was both open and extensive. This second regime was rooted in the way cotton growth was defined at that time based on the market economy. The human actors (farmers, industries, and the colonial power) and the artefact (conventional cotton) formed the ST-System of colonial conventional cotton. Their interaction and dynamism formed the ST-system of that historical, colonial period around cotton growth. This regime which constituted this ST-System would shape future interactions between actors in cotton growth.

6.4. Cotton Growth System in Post-colonial Burkina Faso from 1960 to 1991

The first stage of Burkina Faso's reform process in the post-colonial era focussed on strengthening local institutions and building capacity in preparation for eventual market liberalization (Kaminski et al., 2009). One of the first priorities was to build and strengthen farmers' organizations. The conventional cotton growth regime was a transformation in terms of the work distribution and number of actors in relation to the artefact. The ST-System which developed in the colonial period did not undergo any significant change and some aspects were reinforced during the post-colonial era. The independence of Burkina Faso led to greater understanding of cotton varieties, and the organisation of production developed in new directions.

The market economy objectives of the colonial system called for cotton growth policy changes with regard to the type of cotton grown, the organisation and the purposes of the production. To achieve this the colonial system sought to destabilise elements of the African social context, cultural values, political control and existing market means and ends (Tersiguel, 1992; Konate, 2003). Therefore, before considering the changes which occurred in cotton production during the first three decades of independence, it is important to note the objectives of the post-colonial state, and the way in which they have links to the objectives associated with the colonial period.

6.4.1. Independent Burkina Faso and Cotton Growth

Burkina Faso proclaimed its independence on 5th of August 1960. Yet, as illustrated by Gray (2008), the attention devoted to cotton cultivation remained minimal until the 1970s, when the French cotton development organisation (CFDT) organised the production, processing and export of cotton. "…in 1979 the CFDT partnered with the government of Burkina Faso to create the company called (Société des Fibres Textiles) SOFITEX[38], which then became the main organisation responsible for cotton production" (Gray, 2008: 69) The position of the State subsequently changed because there were no reliable alternative sectors at that time on which the newly independent colony could rely whilst building up its own economy. Consequently, cotton growth, and the agricultural sector more generally, was subjected to some structural and organisational changes (Tersiguel, 1992). The objectives of the independent State were political, economic and social (Ki-Zerbo, 1978; 2003). First and most importantly, the political aim was for Burkina Faso to take over its own leadership and

[38] Is the first and main cotton industry in Burkina Faso. It was SOFITEX which was the only industry for long until cotton sector was liberalized in 2004.

reorganise its political agenda (Goreux and Macrae, 2003; Baffes, 2004). Afterwards, a few intellectuals from the colonisation era promoted the reactivation of the country's cultural and social values, citing the need for these values to be integrated into the educational system (Hazard, 2003; Nacanabo, 2003). Eventually, the post-colonial State integrated cotton growing into its plans for achieving economic development and economic independence.

6.4.2. Organisation of Cotton Production

In the post-colonial era, the type of cotton grown, the organisation and purposes of cotton production underwent some changes (CNRST, 2007). Cotton varieties were improved into conventional cotton to produce more cotton quality of seeds by means of targeted, comprehensive research which included the growing system as a whole. More productive varieties were found and cultivated (Kaminski et al., 2009). In addition, research was done locally. For instance, The French textile company (CFDT) was working directly with the research structure and institutions such as the research institute (IRCT) in order to improve cotton crops' efficacy (CNRST, 2007).

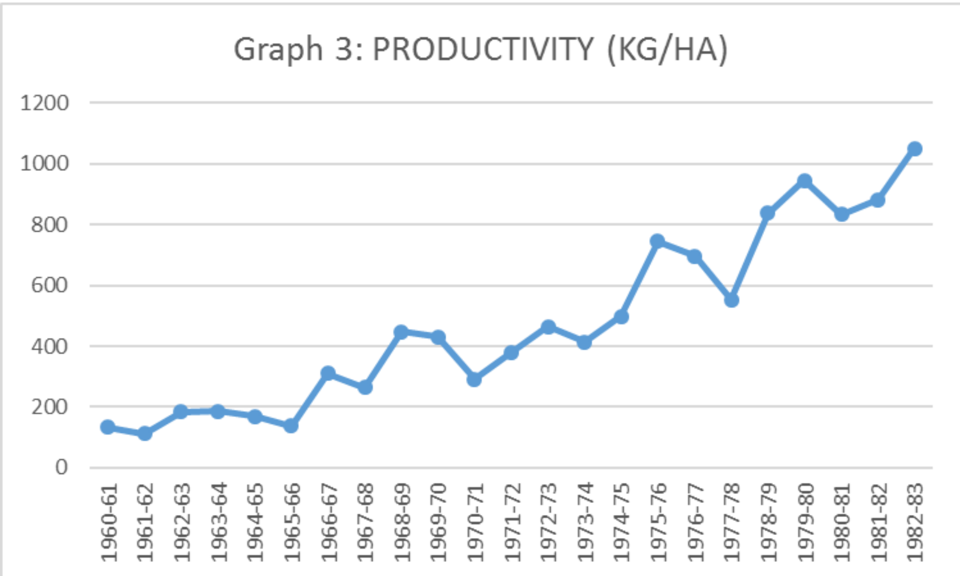
Crops were constantly renewed in order to consistently realise the highest quality product and productivity (Schwartz, 1995) to meet market needs. For instance, the fibre was tested to the requirements of industrial processing and therefore some varieties of cotton had an important boost during the first decades of the post-colonial era. "Gosypium Arboretum" from East Africa and India was the most suitable variety and underwent extensive research to increase its productivity and create new varieties (CNRST, 2007; AFD, 2008). The African Institute (IFAN/ Burkina Faso) became the Voltaic Research Centre (CVRS) in 1964 and National Centre of Research in Science and Technology (CNRST) in 1978 with more detailed organisation in the different development sectors (Zoungrana, 2003).

6.4.3. The Development of the Market Economy

The post-colonial market, following in the footsteps of the colonial era, became one which aimed at increasing productivity for increased profit and competitiveness. The organisational system already created by the colonisers was reorganised. While some structures disappeared, others' duties were extended through CFDT, the French company which until this time had remained the leading institute in the cotton growing system in the whole of Burkina Faso. In practice, CFDT controlled research, loans and organised training to improve farmers' skills in the growing process. Cotton farmers, instead of merely constituting a subservient labour force, became actors in the process of cotton growth. This led to the abolition of the teamwork structure instituted in the colonial epoch and a move towards individual farming (Roberts, 1995; Pare, 2001). Furthermore, from 1964, it became important for the independent government to have a local industry for fibre transformation (spinning and weaving), which until then had been done in the mother country. If spinning had disappeared from villages, weaving remained manually done but in a professional way with more efficient tools. The voltaic textiles (VOLTEX), a cotton company was already effective in 1968 for making clothes (CNRST, 2007) and gradually four other firms were born: one in Bobo Dioulasso in 1970, one in Hounde in 1978, one in Dedougou in 1981 and another in Bobo Dioulasso in 1981. All were founded to support the spinning process (Schwartz, 1995).

6.4.4. Tools and Techniques

In addition, techniques, methods and tools were improved. There was more focus on cotton care and more land used for cultivation. The Volta extended land (AVV) of Nagreogo is an example of land extensions done by the State (Gray and Kevane, 2001). Free internal migration for cotton cultivation was encouraged. This showed how far cotton had become the foundation of the economy of Burkina Faso after colonisation. Cotton growth for the first two decades was spectacular in terms of productivity as well as quality. Between 1970 and 1980, 77,500 tons of cotton grain was sold and $8,604 of the total price returned to farmers (Schwartz, 1995). Finally, cotton production, as in the colonial period, remained a primary cash crop in agriculture and continued to serve as a vital catalyst in the development of Burkina Faso. Thus, cotton production showed a more or less steady upward trend from 1960 until 1982 as shown in graph 3.



Source: processed by author from Schwartz, A. (1993). *Brève histoire de la culture du coton au Burkina Faso*. Paris : ORSTOM.

CNRST (2007). "Production cotoniere au Burkina Faso, La Recherche, un Maillon Essentiel'." *Revue Eureka.*

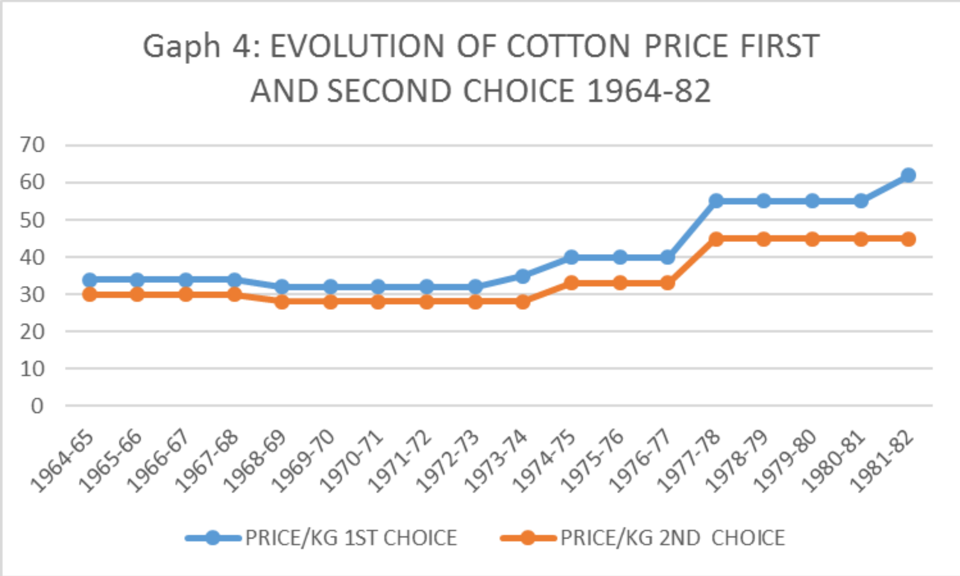
AfDB, OCDE, PNUD, (2014). African Economic Outlook. Burkina Faso. 2014

The cotton growth expansion strategy involved substantial government intervention such as 'contract farming' in which State controlled companies carried out research on cotton, farmer's education, and improved fertilizers. In addition, loans and marketing services were created (Kaminski et al., 2009). For example, in 1971-1976 a project on cotton made available $5,326.4 million from the World Bank, FAO and the government to increase cotton productivity in the western part of the country (Goreux and Macrae, 2003; Gray, 2008). This was led by CFDT which was in partnership with the State from 1970. This partnership led to the creation of voltaic textile (SOFITEX), which replaced CFDT which was a French Textile company (ibid). In this partnership, the State had 65% of the capital against 34% for CFDT and 1%for banks (CNRST, 2007). However, whatever remained of the traditional market was further undermined. Farmers were fully involved in cotton cultivation and had access to loans. They were organised in teams (GV) within their villages in order to receive loans collectively, but the work was done individually. After independence, the government did not allow farmers to sell their cotton products on the local market. This policy was seen as a means of protecting farmers from free-market perils (Gray, 2008).

Another important aspect of government support concerns the cash payment from which farmers benefited with CFDT. This payment was discontinued after 1978 when SOFITEX took over leadership (Baffes, 2004). Due to substantial increases in yields and to growing interest among farmers, cotton areas increased very rapidly after Upper

Volta's independence in 1960. The CFDT remained a key player, associated through a partnership with the new government and with bilateral donors who funded several development projects for cotton in the 1970s. This association was then replaced by SOFITEX (Société des Fibres Textiles) in 1979, which, importantly, was also left in charge of a number of broader rural development projects (Moseley and Gray, 2008). Meanwhile, the rural communities were progressively organized in a cooperative mode through village groups, called GVs, that enabled farmers to self-manage their cotton marketing to SOFITEX and to access input credit through village-level joint-liability schemes (Schwartz, 1993). The introduction of new production techniques (for instance, the ox-plough, mineral fertilization, and pesticides) and high-yielding seeds, together with relatively higher cotton prices, contributed to a two-fold increase in cotton yields from the late 1970s to the 1980s, as well as to increased cereal production and improved food security among cotton smallholders with sufficient cotton profits (Bassett, 2001; CNRST, 2007). It is noticeable from graph 4 that despite the global economic crises between the mid-1970s and 1980s, the value of cotton (first or second choice)[39] on the world market was better than the previous years.

[39] The terms first and second choices are used to qualify the cotton according to its quality. The first choice is the highest quality, the cotton which is quite pure with pretty white color. The second choice is the cotton which has lost its quality either during harvest or on farm. This cotton is quite darker and is sold less than that of the first choice. In addition, the y axis shows the price in CFA as define in Chapter 4



Source: Processed by author from:

Schwartz, A. (1993). *Brève histoire de la culture du coton au Burkina Faso*.ORSTOM

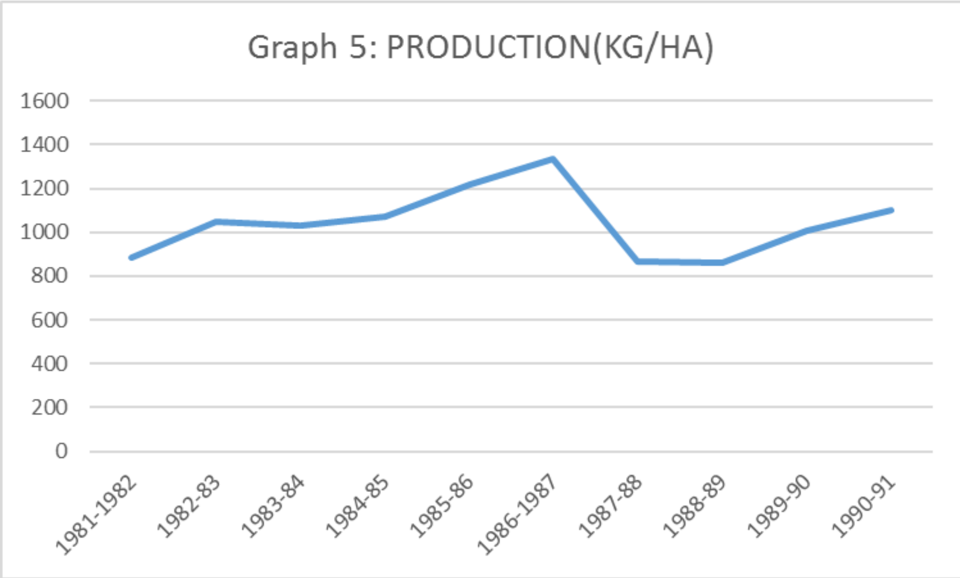
Table 13 : summary of the conventional cotton growth system in post-colonial Burkina Faso (1960-1991)

Actors involved in cotton growth	Variety of cotton	Work organisation	Tools and tool makers	Cotton usages
Independent state, Cotton farmers Blacksmiths, Technical agents, More industries for spinning weaving, Financial backers	Still improved varieties of Gossypium arboretum", "Gossypium hirsutum and Gossypium barbadense	Men growing Industries weaving and spinning. Research institutes doing research	Griots, Blacksmith, (hoes, knives, ploughs,) Tractors, Insecticides and fertilizers	Exclusively commercial on the world market

Source: Processed by author

To summarise, it is important to stress that the most significant change during this period was the freedom in cotton growth implementation between and among the set of actors involved. Farmers who were not included among the beneficiaries of cotton growth under the colonial arrangements became effective actors. The most noticeable change from the colonial ST-System to the new, more independent system was mainly political. The type of cotton, the artefact and the commercial usage did not change. What significantly changed was the organisational dimension with more actors involved.

Between these two regimes (colonial to independence) the changes were in terms of actors and their involvement with users and producers. It has been shown that during the first decade after independence (date range) there was a great increase in cotton production, which was initially very successful (Schwartz, 1993; Bassett, 2001; Gray, 2008). The literature and many reports show that cotton growth progressed until around 1987. One thing to mention from the graph 4 is that cotton production has significantly taken on greater proportions where more land was used in cotton growth. The production reached 169, 227 tons between 1986 and 1987 as graph 5 shows below. Then it went down the following four years due to uncertainty in the immediate post-revolutionary period but also because of the fact from this period, insect damage was becoming part of the concern facing the cotton sector.



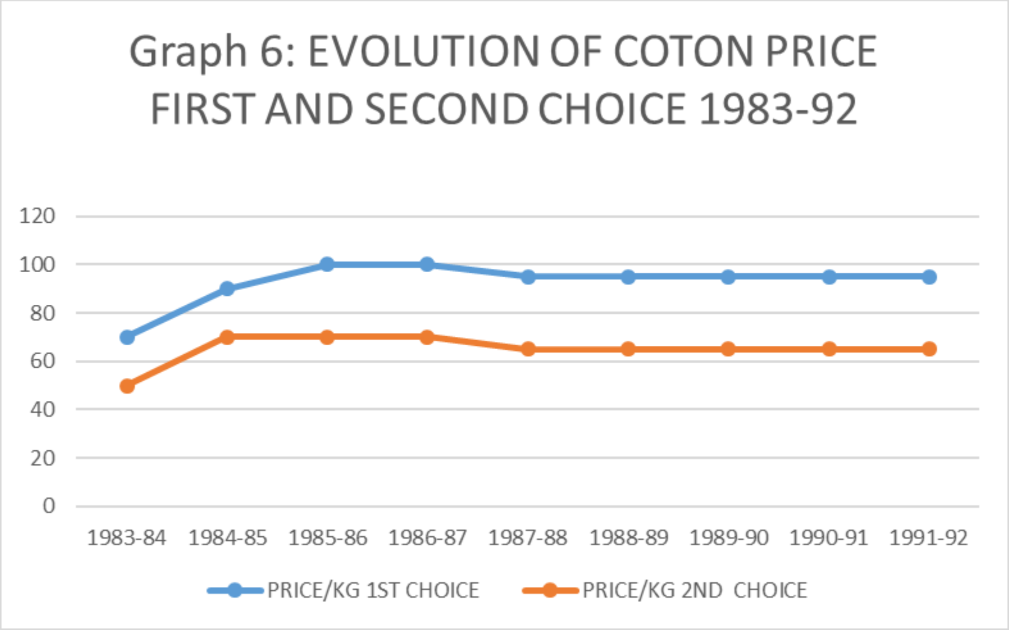
Source: Processed by author from:

Schwartz, A. (1993). *Brève histoire de la culture du coton au Burkina Faso*., Dakar: ORSTOM.

Burkina Faso, Ministère de l'Environnement et du Cadre de Vie (MECV) (2011), Analyse Économique Du Secteur Du Coton Liens Pauvreté Et Environnement Projet Initiative Pauvreté Environnement (IPE), report and Agrer (Bruxelles): MECV

UNPC-B. (2007) Etude sur l'analyse et les stratégies de développement durable de la filière coton. Version intermédiaire, Ouagadougou: UNPC-B

In contrast to the previous pre-revolutionary period, the value of cotton on the market increased during the following 5 years during the revolution. If this can be linked to the global dynamic on the world market, it is important to consider the political context of the period has played a key role.



Source: Processed by author from:

Schwartz, A. (1993). *Brève histoire de la culture du coton au Burkina Faso*.ORSTOM: France

The independent regime did not make fundamental structural changes during those first three decades. Burkina Faso built up its cotton growth policies still based on the colonisers' model but cotton had significantly contributed to social and moral welfare from the 1960s to the 1980s and onwards. Therefore, the common aim of these two regimes remained the pursuit of economic growth. This new production regime adopted liberalisation policies in 1991, when cotton growth was left in the hands of private institutions, but in terms of users and producer linkages the actors remained the same. A new ST-System was born without significant change in the organisational level of the existing colonial regime.

6.5. Cotton Growth Regime: From 1991 to 2003

Another reform sought to maintain the benefits of contract farming—such as potentially higher repayment rates and higher input use—while inducing greater efficiency through private-sector participation. The government took a number of steps towards liberalising cotton markets, starting with allowing the private sector to provide functions for which the State had no comparative advantage (for instance, in areas such as input provision, transport services, and cotton refinement, but not research and development– (Kaminski et al., 2009: 90-92). In 1991 Burkina Faso entered into the Structural Adjustment Programme (SAPs)[40]. The SAP emerged in the 1980s and stressed a neo-classical view of economic freedom, promoting ideas of a free market and competition (Dollar and Svensson, 2001). In contrast to the modernisation theory of economics, the State here is considered as an obstacle to development, because the SAP undermines the coordinating forces of the market and its high spending on productive services and, therefore, was regarded as imposing a burden on factors supposed to lead to economic growth (Berg, 1989; O' Brien, 1991). Development policies, which allow less government intervention, would liberate the market forces for the benefit of individual and national prosperity (Meier and William, 1989).

In the 1980s, SAPs were formulated to re-establish the conditions for a free market (World Bank, 1981; 1986; 1988; 1990). They centred on the following immediate objectives: the redefinition of priorities for development and the mobilisation of resources from international organisations based on projects around those priorities (UNICEF, 1987; Tarp, 2002*)*. In line with neoclassical economic thinking, this

[40] **Structural adjustment programmes** (SAPs) consist of loans provided by the International Monetary Fund (IMF) and the World Bank (WB) to countries that experienced economic crises

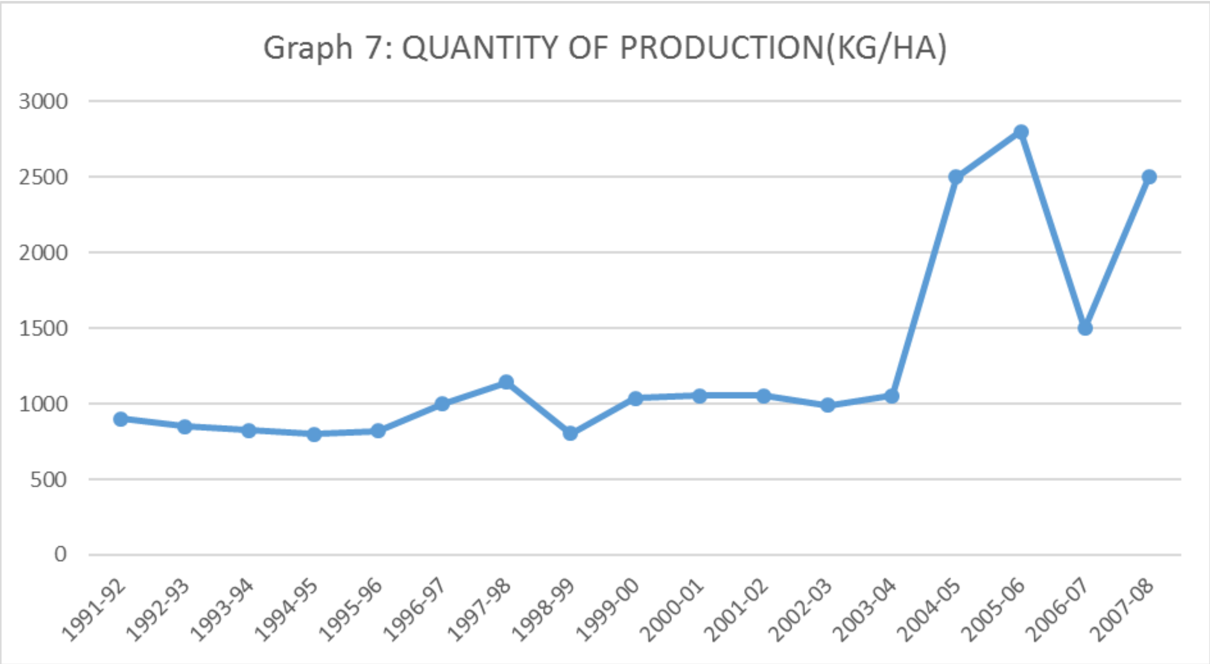
approach called for less involvement from the State in enterprises and marketing. “This was the essential thrust of the strategy, known as structural adjustment, which was soon applied in much of the Third World” (Rapley, 1997: 2). To clarify:

> …In the Third World, neoclassical theory has been embodied in structural adjustment. Essentially, structural adjustment seeks to make both the state and the market more efficient in such a way as to accelerate growth and eliminate waste. […] it places the market at centre stage, assigns the state a secondary role in development, and puts its faith in the potential of unfettered individual initiative, creativity, and ingenuity (Rapley, 1997: 71).

SAP involved privatisation of State owned enterprises, trade liberalisation, currency devaluation, and new private foreign investment in industry. It sought to increase the power and freedoms of entrepreneurs and investors (Rapley, 1997). IMF and World Bank packages played an important role in the process, because they were willing to lend money to countries who met these new criteria (Tarp, 2002). Yet, structural adjustment contained its own problems. Its shortcomings continue to shed a new and damaging light on neoclassical theory (Tarp, 2002). With privatization, economic growth was still weak with some profound turbulence related to the donors wanting to impose their own desire on how the resources developing countries borrowed should be used (Meier and William, 1989). For instance, the World Bank provides the aid, but also specifies where and how this aid is to be used. As Rapley puts it:

> Structural adjustment yielded some positive gains in the more advanced Third World countries. However, in the poorer countries, those most in need of rapid change, it was less effective and may even have done more harm than good” (1997: 2-3).

The cotton expansion strategy in the 1990s involved substantial government intervention. At this stage there was "contract farming" (Kaminski et al., 2009), an arrangement in which the State controlled cotton companies by providing research, loans, marketing and farmers' education. In the graph below, cotton production per ha has been around 1000 kg/ha since the 1990s. It was until 2004 that we can notice a rise in the quantity of cotton produced per ha. The highest quantity of the period was 2800 kg/ha between 2005 and 2006; then, it dropped the following year to 1500kg/ha from graph 7.

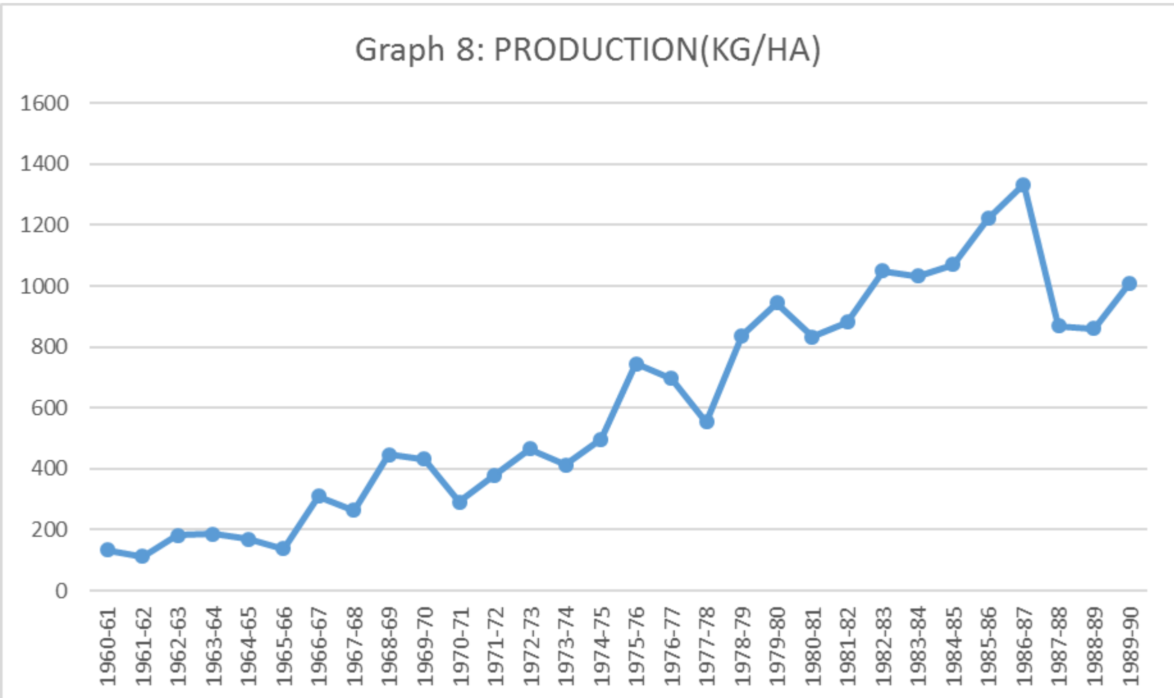


Source: Processed by author from:

DGCOOP, SP/CPSA, SP/COTON, (2007), Diagnostic de la filière coton et identification d'axes stratégiques and FAO (2014) Analyse Des Incitations Par Les

Prix Pour Le Coton Au Burkina Faso Pour La Période 2005-2013, Ouagadougou : Ministry of Trade

One can clearly notice that the quantity of cotton between 1986 and 1987 was around 1,400 kg/ha (graph 8). This achievement did not happen again until 2004-2005. However, as graph 7 shows, while actors in the cotton sector were debating on Bt cotton, it is obvious that, the production between 2004 and 2005 reaches its level of 1986-1987 (graph 8). Such achievement was unique in the history of cotton production in Burkina Faso. This raises the question of the technical relevance of the Bt cotton adoption which will be discussed later in the following Chapter 7.



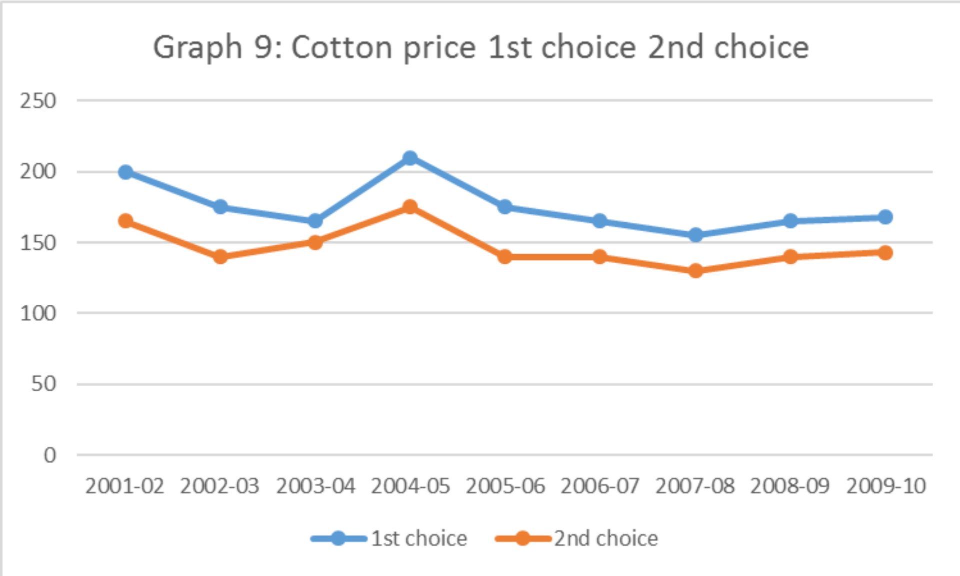
Source: processed by author from:

Schwartz, A. (1993). *Brève histoire de la culture du coton au Burkina Faso*, Paris : ORSTOM. http://horizon.documentation.ird.fr/exldoc/pleins_textes/pleins_textes_6/b_fdi_43-44/010005872.pdf

However, by the late 1980s under SAP, the State-led strategy had become widely criticised by financial backers (World Bank, 1990; World Bank and United Nations Development Program, 1989). Therefore, in 1991, within a liberalisation context, cotton was left in the hands of private institutions (Zoungrana, 2003). In this new system (SAP), State capital was reduced and government actions limited. According to the financial backers, these new socio-technical and political conditions would give a new strategy to cotton farming, with an increase in receipts and allow the country to achieve economic independence (World Bank, 1999). The Structural Adjustment Program in Agriculture (SAPA) considered that such privatisation would also help counter the difficulties that cotton cultivation faced at the end of the 1980s (World Bank, 1981; 1986; 1988; 1990). For the promoters, the SAPA was supposed to make Burkina Faso's cotton more attractive to the world market. The World Bank and French Aid (AFD) strongly supported a reform process, acknowledging that the cotton sector was too important to ignore (World Bank, 1999; Kaminski et al. 2009). The ideology of the market economy was the leading force in this agreement between the State and financial backers such as the World Bank and IMF (Sissao, 2003).

The organisational dimension with regards to labour distribution did not undergo any significant changes, except for the growing number of structures or institutions (Zoungrana, 2003). Additionally, the tools and cultivation techniques, including the use of tractors, were good enough to grow cash crops on the large tracts of land cultivated by farmers. The National Union of Cotton producers (UNPCB) was created in 1997 to reinforce the collaboration between farmers and industry (Gray, 2008), since small village-based teams could not do this efficiently. A union was needed to represent small farmers in the different debates around cotton including price fixing, loans and State subsidies (Kaminski et al., 2009). The success of Burkina Faso's reform approach hinged, to a large extent, on government policies, as well as on the ability of the Cotton Producer Groups (GPC) and the cotton union to manage the responsibilities which the government transferred to them.

However, falling cotton prices in the late 1980s led to serious structural problems that were not adequately addressed. As a result, the prices paid to producers declined from 1988 to 1992. GVs accumulated large debts, and at the beginning of the 1990s, production started to collapse. In collaboration with donors, the government initiated a series of financial and management audits of the cotton sectors. There was deemed to be an urgent need to reform the sector, exacerbated on the political side by the "Dédougou riot" and the partial boycotting of production by growers in 1991, which eventually led to the establishment of the first national growers' union, the FENOP, to defend their interests against growing corruption among officials and SOFITEX (cotton industry) executives. Another key development was the increasing problem of insect damage to crops, which over time had a significant impact on productivity. However, the common shared argument among proponents of the innovation regarding the fall in price and productivity cannot be substantiated as the data showed from graph 9 that between 2004 and 2005 the price of cotton increased two times compared to the period from 1980 onwards, as graph 6 above shows.



Source: Processed by author from:

Evolution de la production et des rendements moyens par région cotonnière de 97/98 à 99/00, SODITEX Site web ; Evolution de la production et des rendements moyens par région cotonnière de 2000 à 2004, Ouagadougou : SOFITEX.

David L. Tschirley, Colin Poulton, and Patrick Labaste, (2009) 'Organization and performance of cotton sectors in Africa: Learning from reform experience, World Bank, Washington, pp.180–1.

Table 14: Summary of the conventional cotton growth system in post-colonial Burkina Faso (1991-2003)

Actors involved in cotton growth	Variety of cotton	Organisation	Tools and tool makers	Cotton usages
Cotton farmers Blacksmiths still present, Technical agents, More industries for spinning weaving, Financial backers	Still improved varieties of Gossypium arboretum", "Gossypium hirsutum and Gossypium barbadense	Men growing Industries weaving and spinning. Research institutes doing research	Griots till present, Blacksmith, till present (hoes, knives, picks, axes, ploughs), Tractors, Insecticides and fertilizers	Exclusively commercial on the world market

Source: Processed by author

The privatisation of 1991 did not significantly change cotton growth systems with regards to the actors involved. The existing ST-System was not significantly affected. From 1991 the government re-configured cotton as an artefact and reduced its own involvement in cotton production. From then on, farmers became greater participants in decision making related to cotton and to aid them, created a national farmers' union (UNPC-B) in 1997 (Bassett, 2008). The interaction of the different actors, who constituted the new system, gave new consideration to the artefact (cotton). Meanwhile, the government intervened again to recapitalize 94 cotton firms as a means of shoring up the sector before new private investors came on board. This shows that "although decision-making under the new institutional structures in the sector has not been error free, problems have been addressed relatively quickly and in an appropriately consultative manner" (Kaminski et al., 2009: 94).

At that time there was close collaboration among SOFITEX, the cotton farmers' union, researchers, and the private sector in the process of searching for sustainable solutions for the cotton sector. This evolution was one of the most significant outcomes of the entire reform process. This was the context into which Bt cotton (the new artefact) was introduced. The strategy of its introduction will be described in the following chapter.

6.6. The Sectoral Innovation System of Cotton

Before around 2000 there was a successful, sophisticated (sectoral) cotton innovation system in Burkina Faso, as well as a sophisticated contract research system. This system was developed before colonization. Cotton farming is a vertically integrated sector where the SOFITEX which is a public enterprise was established and granted a monopoly over cotton production for the purchase of seed cotton and its inputs (seeds, fertilizers and pesticides). It also provided technical support to farmers and financed cotton research. One result was that farmers could only sell their seed cotton to SOFITEX. This system also allowed small farmers to obtain credit easily. In addition, as demonstrated in chapter 4, there were successive innovation systems which evolved over time. In terms of actors, the cotton sector has its own specific program, a specific financial system, a well-defined research system as well as cotton producers. Since independence, this system of actors has worked well and achieved economic growth as shown in graphs 5 to 9 in Chapter 6. The existing cotton system has reached a level were the different actors, farmers, industries, researchers and the State, were in a sort of platform where decisions regarding the sector were discussed and agreed by actors' representatives. However, as can be seen, even with remarkable economic growth in the sector, in such a closed system, the more powerful actors such as the industries, gained more than the farmers, most of whom had small farms. In other words, the existing cotton systems were empowered by strong actors such as industries.

6.7. Conclusion

This chapter has identified the three main ST-Systems or regimes in relation to cotton growth in Burkina Faso – prior to 2003 - and explored the ways in which the shift from one system to another took place. These regimes are: the pre-colonial; the colonial; and the postcolonial (which officially ended in 2003) leaving the way to Bt cotton system. The analysis reveals that the co-evolution of cotton production, the political economy of Burkina Faso, forms of social organisation, and institutions with human actors, gave specificity to each ST-System at a given time. In other words, the type of cotton, the growing techniques, the organisation, the involved actors and the purpose of cotton growth were all specific to each historical epoch.

The findings enable us to evaluate the impact of colonisation on the development of modern economy in Burkina Faso. The analysis illustrates the usefulness of the theoretical framework developed in Chapter two in understanding the shift in regimes and how human and non-human actors are all part of the process of regime shift. It attests that there is a strong relationship between social actors and the knowledge they produce, as seen in the way techniques, tools and knowledge became embodied within a specific regime. This suggests that some ST-Systems are influenced by the knowledge and the interests put forward by social actors. For example, in the colonial and post-colonial ST-Systems, the economic interest in cotton growth was more dominant, while in the pre-colonial ST-System, local and familial subsistence interests tended to dominate. As can also be seen, cotton production techniques and methods are related to the context and the period they develop in.

Each of the ST-Systems had characteristics which were formative in relation to the next ST-System. Each system proved to be vulnerable to external interventions, whether it was political or economic or a combination of both. Each new system produced initial and quite dramatic improvements, just as each new system experienced subsequent falls in production and productivity. The last ST-System of conventional cotton, the postcolonial regime, faced increasingly severe insect-resistance difficulties which undermined the system. It was a problem for which conventional approaches –greater use of increasingly powerful insecticides – were not providing an effective solution. This circumstance was ripe for a search for new developments at niche level.

These developments are important to understand because of their effect on the context and process through which Bt cotton came to be introduced. Biotechnology emerged in the early 1970s and came to maturity with the demonstration of possibility of genetic manipulation and with biotechnology industry in 1980s (Wright, 1994). Herbicide-resistant plants and seeds are engineered to combine and produce their own nutrients. Bt (Bacillus Thuringiensis) cotton portrayed the new seed as a cure-all for the many challenges farmers face. Bt cotton was created by genetically altering the cotton genome to express a microbial protein from the bacterium Bacillus thuringiensis. It is an insect-resistant transgenic crop designed to combat the bollworm. In short, the transgene inserted into the plant's genome produces toxin crystals that the plant would not normally produce which, when ingested by a certain population of organisms, dissolves the gut lining, leading to the organism's death (http://cottonaustralia.com.au/cotton-library/fact-sheets/cotton-fact-file-biotechnology). These genes encode for the production of insecticidal proteins, and thus, genetically transformed plants produce one or more toxins as they grow. There are three different types of Bt cotton:

- Bollgard I contain one gene from the naturally occurring soil bacterium Bacillus thuringiensis (Bt)
- Bollgard II Contain two genes from the naturally occurring soil bacterium Bacillus thuringiensis (Bt)
- Bollgard III contain three genes from the naturally occurring soil bacterium Bacillus thuringiensis (Bt)

These genes are supposed to give the plant an in-built tolerance. Monsanto, one of the America leading biotechnology company in agricultural research is the owner of the Bt cotton seeds gene and is widely promoting its great positive impact on cotton production and poverty alleviation.

The analysis of this phenomenon is central because the introduction of Bt Cotton, while disrupting the existing ST-System, relied upon features of the last conventional cotton system in the successful development of a new ST-System. Specifically, the ST-System of Bt cotton built on the institutional model, structures and organisational capacities already developed by the State, resulting in the formation of the biotechnology innovation strategy. By analysing the mechanism underlying the network of actors and their behaviour in the Bt cotton innovation diffusion processes, it will shed light on the kind of innovation diffusion approach used to adopt and implement it, in a context where the NIS policy tool was adopted, implemented and diffused at national level in Burkina Faso.

Chapter 7: Assessing the NIS Diffusion in Bt Cotton Implementation in Burkina Faso

7.1. Introduction

Chapter 6 has identified three main ST-Systems in relation to cotton growth in Burkina Faso – prior to 2003 - and explored the ways in which the shift from one system to another took place. Continuing this analysis, the present chapter is about the shift to the Bt cotton innovation system. In doing so, it will investigate the innovation diffusion approach which informed Bt cotton implementation. This will help answer the following question: to what extent can it, or can it not be claimed that the National Innovation Systems (NIS) policy tool was diffused at operational level with particular reference to the cotton sector and the introduction of Bt cotton. This chapter will then evaluate the outcome of the implementation of the NIS policy tool at operational level. This will involve an analysis of the way different actors actively or passively intervened in the construction of the Bt cotton system.

Taking the two projects, NIS as a policy tool and Bt cotton innovation, as an operational case study, this chapter argues that the NIS as an innovation diffusion tool did not manage to build a socio-technical system strong enough to uproot the existing socio-technical system of 'training and visits' which had been used as an innovation diffusion approach in cotton sector since the end of the 1980s. For reasons that will be explained, the NIS policy tool, which was not fully implemented at the strategic policy level (Chapter 5), has not been implemented at all at operational level in the cotton sector. This was the result of complex factors independent of the intrinsic qualities of the NIS policy tool.

The analysis in this chapter begins by describing the difficulties in conventional cotton growth and by characterising the evolution of the problem in cotton production for which the development of Bt cotton technology was intended to provide a radically new solution. It describes the emergence and stabilisation of the ST-Regime of Bt cotton by addressing the way in which the transition comes about through actors' network building and the construction of expectations around technology development. Then, it describes the underlying innovation approach which justifies the way that Bt innovation was adopted and implemented through the way the involved actors behaved. The outcome of such a process will be clearly defined at the end of the chapter.

7.2. The Emergence of Bt Cotton in the Context of Persisting Development Problems

Productivity decreased dramatically after the end of the1980s, and declined further during the 1990s as the land for cotton growth expended (CNRST, 2007), because cotton farmers, related industries and the government were failing to control cotton pests and thereby risked losing Burkina Faso's leading role in cotton cultivation in Africa. It became imperative that researchers looked for efficient solutions (Schwartz, 1999; CNRST, 1994; 1995; 2007; CES, 2011).

Other persistent and related problems, such as soil degradation and climate variation, combined with a lack of crucial rainfall, hindered cotton growth development (CNRST, 1994). Conventional cotton, which had been cultivated since the colonial era, and expanded in the post-independence era, was no longer a very promising prospect (Schwartz, 1997, Gray, 2008).

Once again, the problem was seen from a technological perspective. From the 1980s, it was argued that a "specific cotton research sector was necessary to increase its productivity" (CNRST, 2007: 26). INERA, the national agricultural research centre was formed and carried out intensive research through the creation of a specific cotton research programme (CNRST, 2007; Gray, 2008; World Bank, 2007). In doing so, they hoped to remedy the disasters relating to insect resistance which cotton farmers in Burkina Faso were facing (CES, 2011).

Production became increasingly susceptible to frequent drought and insect infestation, which damaged up to 90% of the country's cotton crop despite great efforts made by the research programme on cotton growth (Goreux and Macrae, 2003; CNRST, 2007; CES, 2011). In the 1990s, Burkina Faso was therefore witnessing a drop in its cotton production, just like its neighbouring countries, Mali and Ivory Coast (Roberts, 1995; Baffes, 2007). The problems discouraged many actors involved in cotton growth, specifically cotton farmers who were losing hope over the future of their cash crop.

In Burkina Faso, as in other West African countries, cotton growth became dependent on more frequent insecticide treatments. The six to eight treatments recommended took more time and the additional expense significantly reduced Burkina Faso's competitiveness in the world market (CNRST, 2007). Farmers, as well as researchers and industries, were looking for an alternative crop to redress the decline (Schwartz, 1991; 1993; Gray, 1999; 2005; 2008; Roberts, 1995). As a result, though highly contested, biotechnology[41] was seen as a solution which would increase cotton production and allow Burkina Faso to be competitive on the world market (Illy and Zangre, 2003; CES, 2011). A meeting with Monsanto in 1999 in Cameroon created an opportunity to establish a new platform for solutions to cotton productivity problems. Bt cotton, an insect-protected cotton contains a protein from *Bacillus thuringiensis* (*Bt*). It protects cotton plants from specific lepidopteron insect pests (ISAAA, 2006; CNRST, 2007, CES, 2011). The company is also doing research on many other crops such as Bt maize, Bt soy bean, and so on. With respect to Bt cotton, Monsanto believes that its technology is able to fight against insects, environmental pollution and climate variation, and therefore enhance economic development through a much-needed increase in the quality and quantity of conventional cotton productivity. Monsanto remains one of the top leading industries in agricultural biotechnology in the world. Bt cotton was considered to be effective in controlling the bollworms [type of insects] that destroyed the cotton plants and negatively impacted on the harvest. It was also known as Bollgard II, which literally translates as 'capsule guardian'. However, Bt cotton was regarded as controversial because of division in public opinion regarding its adoption.

[41] the exploitation of biological processes for industrial and other purposes, **especially the genetic manipulation of microorganisms for the production of** antibiotics, hormones, etc. – in my case it refers to genetic modified crops

7.3. The Opening of Windows of Opportunity for Bt Cotton

The meeting in Cameroon in 1999 on biotechnology, in which Burkina Faso took part, marks a decisive step in the adoption of biotechnology cotton by the actors involved in cotton production in Burkina Faso. The government sent the director of the National Agency for the Use of Research Results (ANVAR) to make a presentation on traditional biotechnology and the problem of insect resistance in cotton growth in Burkina Faso. This led to his first contact with Monsanto, who made a presentation on Bt cotton. The relationship between research activities and agricultural problems particularly with specific regard to cotton was presented by the director of ANVAR, and the proposed solutions put forward by Monsanto brought the apparently mutual interests of both actors to the fore.

In the history of Bt cotton in Burkina Faso, this conference can be considered as the beginning of a long process of negotiation between Monsanto and the different local actors. A major participant from Burkina Faso stated the context of their meeting with Monsanto and he underlines how their mutual interest came to meet together during that conference. He attests that:

> After our presentation, Monsanto met us to discuss. He was interested in Burkina Faso. So Monsanto is already therefore an actor, a main actor. Me, I was representing the research, but I was the interface, because I was there under the Agency [ANVAR] for the use of the results of research. Then we were two actors. He [Monsanto' officer] said he was interested in Burkina Faso, Mali and Ivory Coast. I said there is no problem, but, because I'm an individual representing the country, I cannot make any decision of such importance. But I suggest that he can come to Burkina, we are going to organise a national forum where he is going to present his Bt cotton. And this happened in 2000. (Interview#1)

The Cameroon conference in 1999 ended with Monsanto expressing interest in transferring its Bt cotton (a type of GM cotton)[42] to Burkina Faso, and the ANVAR director indicating interest in that technology being used in Burkina Faso. As a researcher and a national innovation institute director, his personal interest would probably be shared by the institution he represented. As can be seen, Bt cotton had already been developed at niche level at Monsanto's laboratory in USA. The meeting in Cameroon opened up opportunities to interest actors in Burkina Faso because of the problems the cotton sector was facing.

The first meeting with Monsanto in Cameroon in 1999 was followed by official meetings with Monsanto in 2000 and then in 2003 in Burkina Faso. In those meetings, the different interested parties (researchers, industries, farmers and government representatives) were concentrating on the problem of insect damage to conventional cotton and the solution brought forward by Bt cotton. "All the actors present at the first and second meeting had shown an interest towards biotechnology cotton to fight against the insect damage" (Interview#1). Additionally, during the workshop organized by the President's advisors, held between 29th of March and 19th of April 2011, the National Union of Farmers, industries and government representatives agreed that biotechnology cotton was one alternative in the fight against insect resistance. The details of the problematisation by the different interested parties are described below.

[42] It is cotton in which we insert a bacterial gene, and this bacteria is from the soil and was even known to be an insecticide. It means that this bacteria, if we grow it in big quantities and transformed it into powder, could be used as insecticide. On a scientific level, all the plants, animals…have the same DNA, it is only the succession of the unity which is different and which makes the difference between men, monkeys and plants. So [Monsanto researchers] did the test and noticed that if they insert the gene into the plant, the plant develops the toxin like the gene that was in the bacteria from interview data

- **Cotton farmers**

Farmers produce cotton and therefore were directly affected by the problems which plagued the crop from the end of the 1980s relating to pest control and soil degradation combined with changes in the climate. This grave situation discouraged many farmers, dashing their hopes and raising doubts about whether they should continue to grow cotton (Tiendrebeogo, 2011). Yameogo, during the 2011 workshop on biotechnology summarised:

> …cotton farmers at this time wanted to stop cotton growth due to the fact that it was so difficult for them to control the insects by using the usual insecticides […] the adoption of Bt cotton was imposed on the actor[s] of the sector. (Yameogo, 2011: 12)

Farmers in this journey of cotton growth were spending more and more money on the care of cotton. Additionally, they were accused by the industry and researchers of not using the insecticides properly and of diverting the use of insecticides from cotton to other crops or selling it at the local market (Tiendrebeogo, 2011). A social scientific awareness would have alerted researchers to the ways that farmers would look for other options to offset the losses from cotton growth, which had started to have adverse effects on their life. For instance, they could not send their children to school, fulfil their social needs or repay their debts to industry. Even if the shift from conventional to Bt cotton would not be without difficulties, it is important to consider the reasons – social and economic – why the average farmer would welcome the promised benefits of Bt technology.

- **Cotton industries**

Cotton industries are the key elements in the cotton growth process in Burkina Faso. They have a monopoly on the materials required for cotton growth and processing and since farmers cannot afford to grow cotton at their own expense, provide them with loans, insecticides, chemicals, tools, etc. for cotton cultivation. In addition, they buy all the cotton from the farmers and process it for world trade. Therefore, the commercialisation of cotton relies not on farmers but on the industries.

The high dependence of cotton on insecticide treatments greatly reduced the industries' competitiveness. They were accused by farmers of giving out ineffective insecticides and other products: "We [the industries] were accused by farmers that our insecticides were not good enough" (Interview#41). Industries could not realise high profits with infested conventional cotton. Given the situation, it became vital for them to find a solution to their economic and social problems. Bt technology, which was supposed to control insect infestation, would be acceptable to this relevant social group as it would help them regain their worldwide reputation. Indeed, "this technology has allowed the countries from the North to face the resistance phenomenon and regain their competitiveness" (Interview #48)

- **Cotton researchers**

Among the actors involved in conventional cotton growth, researchers played an important role through their quest to find solutions to the different problems faced by the conventional cotton plant. Indeed, from 1991, INERA, the agricultural research centre, identified laboratory and field research as the key to solving the problems that farmers, industry and the whole country were facing. The reason behind the fall in production was a combination of irregular climate, soil degradation and insect damage. In 1997, researchers decided that the problem that affected conventional cotton was ‘insect resistance’ (Interwiew#44). After a long period of using the same insecticides, the insects got used to them and no longer died, so, spraying became less effective. Farmers and industry became angry and accused researchers of doing poor research since they were unable to find a solution to the problem. As clearly stated by one of them: “At this point, us researchers were seen as useless by the farmers and the industry which for long time have relied on us in the process of finding appropriate solutions to their cotton growth issues” (Interview#54)

Agricultural researchers were also using traditional methods of biotechnology. Researchers in Burkina Faso knew nothing about modern biotechnology, particularly in relation to cotton and were keen to find out about this new technology to help them solve the problem of insect damage to cotton. Research conducted by Zangre and Massimbo (2002) revealed the huge interest in emerging biotechnology among research institutes and researchers.

- **Civil society**

Biotechnology translation in Burkina Faso includes civil society since, for the first time, it had an important place in technology adoption processes and could positively or negatively affect the process and implementation of innovation, especially of biotechnology cotton. Civil society could be affected by the environmental, health, social, cultural, economic and ethical issues, which are frequently raised in the debate around biotechnology. This relevant social group sees biotechnology as highly controversial and therefore, felt the need to consider it as part of the process of implementation. During the early stage of ‘problematisation’ (Callon, 1986), civil society was considered as one of the key actors. Monsanto was aware of the complexity of the social context described above and therefore sought to integrate this group at its first official meeting with actors in Burkina Faso.

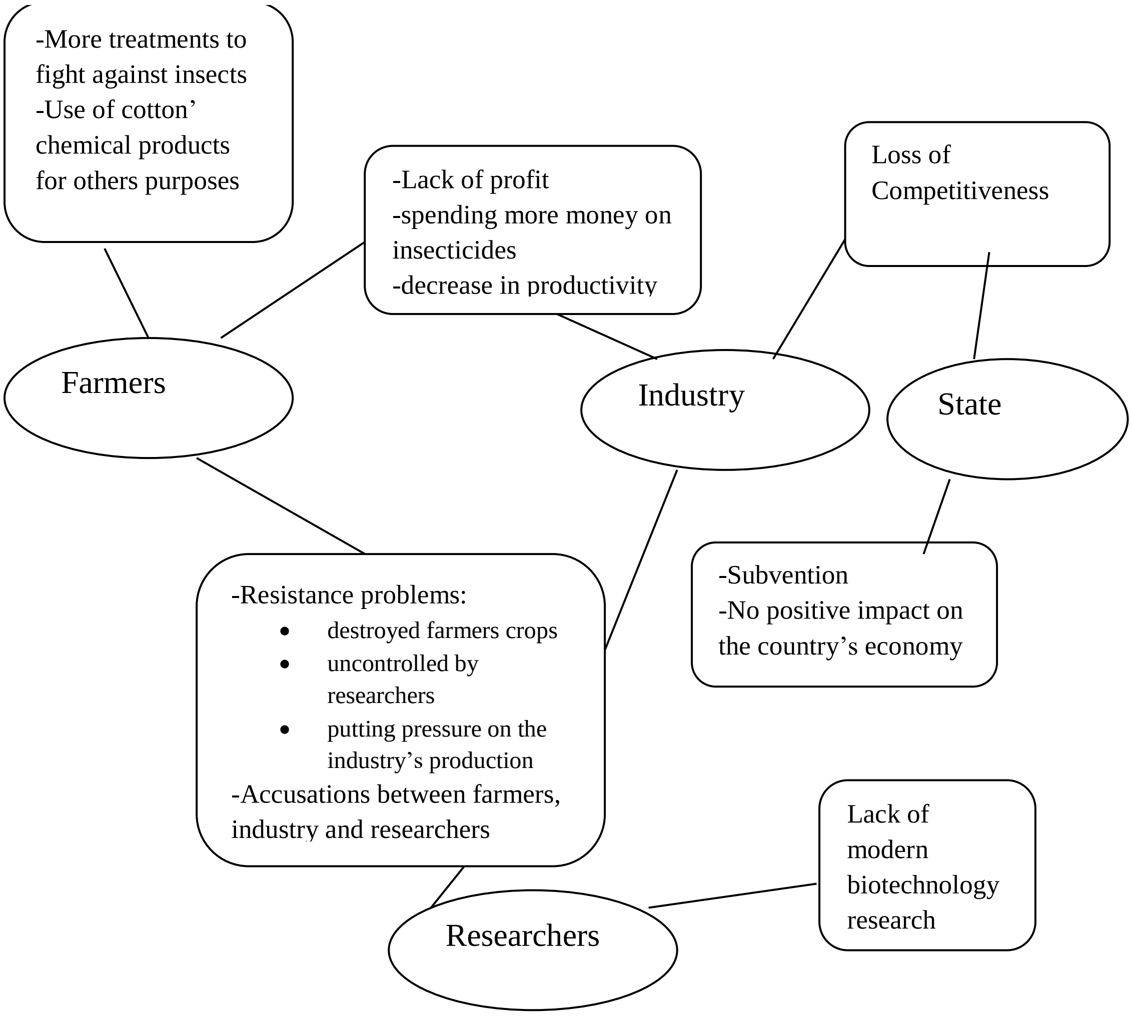
Civil society in Burkina Faso is complex and its composition heterogeneous. It includes people engaged in biodiversity protection, researchers and scientists and the lay public. With regard to Bt cotton implementation, some elements of civil society were involved in the process of technology adoption and made its voice heard. One of the civil society leaders stated that: “It [cotton] was trialled in the country [Burkina Faso] without any rules […] we were those who said no, it was not possible. We said that regulatory framework needed to be put in place before hand […] (Interview#55)

- **The government of Burkina Faso**

In Burkina Faso about 90% of the population is engaged in subsistence agriculture (Gray, 2008). Cotton production constitutes the pillar of the country’s economy (ISAAA, 2006; Tiendrebeogo, 2011). Cotton income contributes to the livelihoods of more than 3 million people, representing around 20% of the population, helping them to sustain their family and send their children to school (ISAAA, 2006). However, as explained above, this main export crop was susceptible to frequent drought and insect damage, making cotton extremely dependent on insecticides. In addition, the government’s subsidies to farmers remained insignificant (Bassett, 2001; 2008). These issues significantly reduced Burkina Faso’s competitiveness on the world market

(Gray, 2008; Bassett, 2008). Bt cotton certainly interested state actors, who envisaged the industry becoming increasingly competitive on the world market through adopting new technology, and the country obtaining a top position in Africa and the world (CES, 2011).

Figure 9: Actors and their perspectives about cotton production in Burkina Faso



Source: Processed by author

The figure 9 gives a map of different actors showing the different actors and their perception of the cause of the issue they were facing in cotton production and which justified a need for them to accept the new technology, Bt cotton. This was the context within which Monsanto found the niches translated through the insect resistance. The biggest issue which derived from that was the mutual accusations among farmers, industry and researchers. This explicitly shows the problematisation of the birth of interest of the relevant social group toward Bt cotton's introduction

Through this problematisation, the different relevant actors directly concerned with Bt cotton were identified. There remained a presumption that these potential actors would be interested in that technology but the remaining challenge for Monsanto was to confirm these interests and place itself as an "an obligatory passage point" in Callon's (1986) terms. That is, to convince these relevant actors (farmers, industries, researchers, civil society, and the government) that their interests lay in admitting Bt cotton as an alternative solution to the problem of conventional cotton production. Two conferences which took place in Ouagadougou, Burkina Faso in 2000 and later in 2003 were used by Monsanto as a platform to provide the information and arguments designed to persuade local actors of the potential of their solution.

The first official meeting held in 2000 was an opportunity for Monsanto to describe the mechanism of Bt cotton and prove its technology's benefits for all the relevant actors in the ST-System of Bt cotton under construction. According to Monsanto:

> Bt cotton is cotton in which we insert a bacterial gene, and this bacterium is from the soil and was even known to be an insecticide. It means that the bacteria, if we grow it in big quantities and transformed it into powder, could be used as insecticide. On a scientific level, all the plants, animals…have the same DNA, it is only the succession of the unity which is different and which makes the difference between men, monkeys and plants. So [Monsanto researchers] did the test and noticed that if they insert the gene into the plant, the plant develops the toxin like the gene that was in the bacteria[43].

[43] A film made by ISAAA in Burkina Faso, 'Seeing is Believing' to show to the different actors in the cotton sector how promising Bt cotton farms are in comparison to conventional cotton. This definition was given by a researcher to the journalist/speaker http://www.naturalnews.tv/v.asp?v=B345F5800F780785C335DF9917F05501 [access date 24/08/2010]

One can see that Monsanto's definition of its technology was well matched to the relevant social groups' worries, suggesting a solution through which farmers and industries would definitely fight against insect resistance without any major changes, given that the technology is part of the normal process of living species.

Monsanto clearly described the benefits of its technology for the different actors. Firstly, for farmers, Monsanto aimed to deliver a product with more potential for insect control thereby providing them with potentially greater productivity in the field. In Burkina Faso, the yield would, it was claimed, increase and the number of pesticide treatments fall from six or eight to two. Secondly, industry would gain more profit and increased competitiveness on the world market. Thirdly, researchers would acquire new knowledge, skills and techniques. They would benefit from the extensive educational programmes for students around the world – particularly in science and agriculture. Monsanto suggested that it would fund numerous research grants for graduate students; work in partnership with government bodies, non-profit agencies and advocacy groups to make agriculture more sustainable (Monsanto, 2011). The State, from Monsanto's perspective, would benefit from being more competitive in the cotton market.

The starting point here is Monsanto, which appears to bring forward a new and promising solution to the crucial problem of insect resistance that the country has been facing since the 1990s. By targeting the relevant actors in this way, Monsanto, as the owner of the technology (Bt cotton), fulfilled the key role as an 'obligatory passage point' (Callon, 1986) within the set of actors in the translation process. As a result, Monsanto put itself in the position of being indispensable in the translation process. This locates the Monsanto laboratory as a technological niche, a place where practical solutions are developed to meet the needs created by the landscape (Geels, 2004).

Figure 10: Benefits of Bt cotton from Monsanto's perspective: How Monsanto places itself as an 'obligatory passage point'

Source: Processed by author

7.4. The Formation of the ST-Regime of Bt Cotton

The different relevant actors were offered reasons to accept that Monsanto's technology would be beneficial to them in many ways, including their own safety [because of reduced pesticide spraying] (Tiendrebeogo, 2011; CES, 2011; INERA, 2011). They were convinced also that Monsanto's technology would conserve energy; reduce greenhouse gases; minimize use of toxic herbicides; conserve soil fertility and natural resources and enable farmers to produce higher quality cotton while conserving more natural resources[44]. During the workshop organised by the President's advisors in 2011, UNPC-B's president to justify their choice and full adhesion to Bt cotton used the same argument that is commonly agreed. He stated that:

> We knew that Bt cotton was very beneficial to us. As farmers, we were suffering a lot, because most of us are manual cotton farmers and we used to walk for several km to spray the insecticides. Now this work load is reduced and [there is] no toxicity due to this product [insecticides] (Interview#57)

It is not surprising that, in particular, farmers' representatives, who participated in the different meetings from the early stages of Bt cotton processes, felt that this technology, by reducing the use of the insecticides, would positively impact on their living conditions in terms of time saved, release from hard labour, the reduction of

[44]Monsanto's definition of its technology, Cotton Trait Performance https://www.monsanto.com/products/Pages/benefits-of-plant-biotechnology.aspx [access date 13/07/2011]

environmental pollution and specifically by safeguarding their health by not requiring them to be in permanent in contact with insect control products (ISAAA, 2006; Gross, 2007; Smith, 2005). It appeared that Bt cotton would enable farmers to protect cotton crops from certain target insects and allow growers to increase both their yield and revenue, while decreasing the use of pesticides by two thirds in Burkina Faso (ISAAA, 2012). An influential representative of cotton farmers summarises these advantages as follows:

> It would reduce our hard work; it was so tiring […] it is not easy because we are [still] doing manual farming [that is to say farmers are still using the traditional tool in the growing systems] so another advantage is related to our health issues because we are not in touch with the insecticides all the time. So this helps a lot (Interview#33).

Many farmers were impressed by the claims made about Monsanto's technology, and became confident of its benefits following the presentation of its advantages in relation to increased yield and productivity. A small farmer says:

> So far, we do not have access to this new crop. If we get it, it will be good […] this is my dearest hope, because pesticides alone eat up a large portion of our profits. […] Since there is no need for pesticide with transgenic cotton, it is something positive for our health and the environment as well (Interview#38).

Other farmers interviewed claimed that Bt cotton would be a better solution for them than the intensive use of insecticides. As its name, Bollgard II, which literally translates as 'capsule guardian' implies, it would help them obtain better harvests and products, and therefore better prices. Additionally, the work was meant to become less exhausting for farmers. So they found that they would be able to rest and spend their time doing other things than growing only cotton (CES, 2011; Tiendrebeoge, 2011).

Bt cotton farming was therefore expected to be a more relaxed job. A farmer confirms that: "If we no longer have to spray the cotton, it is a good thing for us" (Interview#37). Bt cotton was considered to be effective in controlling the bollworms that destroyed the cotton plants and negatively impacted on the harvest. Some farmers were therefore hopeful that they will soon be able to grow biotechnology cotton.

However, before any real 'interessement' (Callon, 1986:1), actors still raised questions and worries related to the solidity of biotechnology cotton in the context of Burkina Faso. This dimension implies the interessement that the relevant social groups have to the technology.

At the first workshop held in 2000, local relevant actors in Burkina Faso raised health-related issues, and, referring to the 1990s resistance issues, the possibility of a new insect resistance were discussed. Some farmers were very concerned about their safety. "We were hearing that it [Bt cotton] makes men sterile" (Interview#20). The important issue of dependency, the concern that farmers would be relying on Monsanto for supplies was also raised. Environmental issues, biodiversity and national rules constituted the preoccupations of the relevant actors regarding the technology.

Relevant groups are still not fully convinced of the short and long-term consequences of the health-related issues. A farmer recalls "It wasn't easy because even the firms who produce the insecticides do not want GM because it will destroy their business, people said it kills people, it kills men, makes them sterile, it kills animals even now" (Interview#40). Most of the different actors, though they were interested in the technology, worried about the human and animal health aspect.

As a GM product, biotechnology cotton would be in direct contact with human and animal food especially in the Burkinabe context. Cotton grain is used in local dishes and there remains anxiety about the impact of Bt cotton grain on people's wellbeing (ISAAA, 2006; Gray, 2008). For example, a participant, during the field visit of ISAAA, 2006, raised this question. "I would like to know if Bt cotton grain is safe, given that in Burkina Faso people use it for oil or soup for consumption. Is the grain safe for these purposes?"[45].

From the interviews that researchers, industries, civil society and farmers gave, however, it was clear that they were mainly worried about the risk of insect resistance to Bt cotton in the long term. The actors concerned were using their previous experiences of insect resistance to evaluate Bt cotton and believed that what happened with conventional cotton could happen again. In fact, when the resistance occurred in the 1990s, it did so following the long term use of the same product, which made insects used to it and unaffected by it (CNRST, 2007). A farmer illustrates this in his

[45]A film was made by ISAAA in Burkina Faso: "Seeing is Believing" to show to the different actors of cotton sector how promising Bt cotton farms are in comparison to conventional cotton. http://www.naturalnews.tv/v.asp?v=B345F5800F780785C335DF9917F05501 [access date 24/08/2010]

own words, saying that: “even now we can see that many people used to take paracetamol for malaria, now we can see this [paracetemol] cannot fight against malaria anymore. It is the same with the long term use of Bt cotton” (Interview#5).

Thus, there was the fear that what happened with the insects’ resistance to insecticides could be repeated with Bt cotton through its use in the long run (Tiendrebeogo, 2011), so that the problems of the relevant social groups could recur. A researcher remembers discussing this issue in the process of adopting Bt cotton, for him, “The technology was good, but we worried about the resistance aspect that was so important in the 1990s and we did not hesitate to discuss this issue with it [Monsanto]” (Interview#6).

Another important focus for the relevant actors was the environmental and biodiversity issue. This was discussed by civil society in the technology’s early stages. Researchers, farmers and the industry raised this aspect as well. Because the non-targeted insects, especially the bees, are useful pollinators, the actors were concerned about their reaction to the new technology. A researcher insists that:

> Until now, there is no, no, no, negative impact on the environment. I can tell you with documents and the conclusion is that GM crops do not pose higher risks than the conventional ones. It shows even that it is the contrary. Conventional cotton impacts negatively on the environment (Interview#8).

By this he meant that Bt is safe and do not present any danger for the environment. The lack of a national regulatory framework was underlined by some of the actors, such as researchers and civil society. They believed the trans-boundary movement of GM crops was something which must follow national rules and the Cartagena

Protocol, the agreement based on the precautionary principle, which the country must adopt before accepting any GM crop in the country. Based on the Convention on Biological Diversity and then the Cartagena Protocol, there was a need for Burkina Faso to be a signatory to the protocol, to establish its national rules on GM (Interview#36). The rules anticipate the potential hazards of genetic engineering applications before the country gives its approval. Employment of the Precautionary Principle (PP) entails identification of risk, scientific uncertainty and ignorance, and involves a transparent and inclusive decision-making processes. A researcher from a civil society organisation suggests that "Burkina Faso needs to abstain for at least three years before any decision [to accept or not Bt cotton] could be taken" [because of the country's lack of a regulatory framework] (Interview#45).

This regulatory issue was raised during the first official meeting held in 2000 during which actors thought that the development of a regulatory framework was the most important point to start from. One of the proponents of Bt cotton has used a defensive argument to show that Burkina Faso was quite aware and familiar with the Cartagena Protocol, he insists that:

> As a member of the Cartagena Protocol and having signed up to it, Burkina Faso needs to set up its own national rules and regulations following the protocol, before any biotechnology adoption […] The actors who were present agreed that this is essential (Interview#42).

- **The issue of Dependency for Access to Bt Cotton**

Civil society, farmers, researchers and the industry expressed worries related to the issue of dependency. By accepting Bt cotton, Burkina Faso farmers and the country as a whole would be dependent on Monsanto for their cotton growth in the future, and the local cotton variety could eventually disappear. An interviewee, a member of a civil society group and the president of an organisation which promotes traditional farming, insisted that:

> GM products are more dangerous than good. It will lead Burkina Faso to total dependence and loss of food sovereignty. As a poor country, BF will be dependent for research and crops. Monsanto, Syngenta and Dupont possess 47% of world GM crops. The country using GM would depend on them for their crop supply (Interview#56).

Finally, some specific worries were raised mainly by farmers and supported by civil society, with regard to the cost of the technology. In the past, farmers spent $8,033 to grow cotton on 1ha. Now for the same amount of land farmers may need to spend more money. This would make the technology inaccessible to small farmers who were originally considered to be the first group to gain advantages from it.

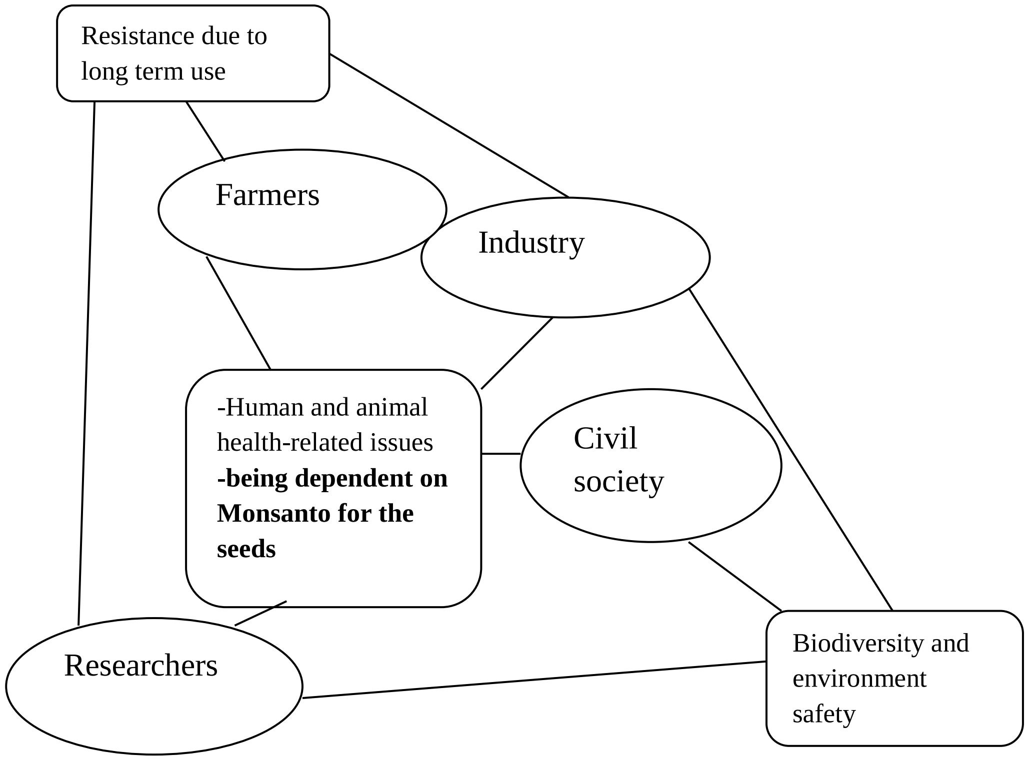
- **Capacity Building and Bt Cotton Adoption**

Some researchers had a specific anxiety related to the capacity building that is needed for the technology to be well assessed before implementation. As one researcher underlines:

> Capacity building was one important condition for this technology. Training first: […] for the use of the technology such as isolating the DNA and introducing it. Now what was missing, […] [was] this capacity building, […] at the end of the experimentation we need to have land, infrastructures, a laboratory with adequate equipment which will allow us to cut the DNA and stick it (Interview#1).

For the above interviewee, there was an important need to reinforce the local research capacity before welcoming biotechnology cotton. This idea was supported by a civil society actor who maintained that "scientific capacity for doing such research needs to be reinforced before decisions can be made" (Interview#1). At the time it was only traditional biotechnology which was examined in the different research centres in Burkina Faso since modern biotechnology was unknown to them. Therefore, some researchers and some civil society actors believed it was high time the country strengthened its capacity for the better use and manipulation of modern biotechnology. Figure 3 below gives a summary of the anxieties expressed by the local actors towards biotechnology cotton.

Figure 11: Bt cotton according to local actors in response to Monsanto



Source: Processed by author

The above figure 11 gives a map of different actors showing the different actors and their shared concerns regarding Bt cotton technology.

7.5. Stabilising the Bt cotton ST-Regime

The landscape development which created pressure on the regime created the space and opportunity for innovation at niche level to uproot the existing regime. Bt cotton, from this perspective, contained features Geels identified as fundamental to the chances of successful innovation: “A specific mechanism in the breakthrough of radical innovations is technological add-on and hybridisation." (Geels, 2002:1271). This section analyses this reconfiguration of the new technology by way of the series of adaptations and changes that Monsanto went through in order to get its technology accepted by addressing the issues raised by the interested parties. In the case of Bt cotton, the original plan of the owner of the technology needed to change in order to fit into the relevant actors' problematisation of Bt cotton. Monsanto re-evaluated its technology from different angles to enable it to fit the context.

7.5.1. The interplay between Monsanto and the local actors

In the case of Burkina Faso, the initial plan for Monsanto was to transfer its pre-existing Bt cotton to Burkina Faso, but during the first meeting in 2000, this plan was reoriented and led to a second meeting held in 2003 where more issues about bio-security were discussed (Ouedraogo, 2003). The different stabilizing changes negotiated by researchers, farmers, industry and civil society actors are addressed below.

First of all, to allay concerns regarding the possible resistance of insects to Bt cotton, Monsanto designed an alternative with the relevant group to sustain its technology and enable it to fit local conditions. For instance, to avoid the issue of resistance, the growing method in the specific case of Burkina Faso consisted of 20% conventional cotton and 80% Bt cotton. A farmers' representative affirms that "Each farmer needs to respect this; the 20% helps as a refuge zone for the pests. Each Bt cotton farmer needs 80% Bt and 20% conventional." (Interview#49).

This option was agreed and accepted by this set of actors, specifically the government which saw its role as protecting farmers' interests and the cotton sector as a whole. "In government policy Bt cotton can be grown on a maximum 80% of the land to avoid any uncontrollable situation. A minimum of 20% of the land is used for the conventional one which is also very important" (Interview#51). Many farmers thought that this solution would fit into the specific context of Burkina Faso and some other countries. It was interpreted to mean also that, if Bt cotton happens to lose its quality in Burkina Faso, going back to the local conventional variety would be a possibility.

Secondly, the experience of local researchers and industries was that the American variety of conventional cotton was not successful in the growing conditions in Burkina Faso. Therefore, they were inclined to use the local conventional cotton for Bt engineering. A researcher at the national institute for agricultural research said that "America conventional cotton was not successful in Burkina Faso farming and it would be more practical thinking about an alternative" (Hema, 2011). In other words, they were sure that the Bt cotton engineered from conventional American cotton would not be efficient. This shows that even though modern biotechnology had not yet been implemented in Burkina Faso, the experience of the relevant group combined with their scientific knowledge had already influenced Monsanto's process and initial plan of transferring its technology to Burkina Faso. Both the non-scientific societal pressure groups and the scientific outsider professionals such as members of a civil society community, CV-OGM, who possessed knowledge of biotechnology, made their voices heard on this matter. Therefore, the relevant social groups requested that Monsanto's technology be derived from the local variety of cotton.

Their reason for the request was twofold: on the one hand, to avoid the sector becoming fully reliant on an agro-business company such as Monsanto; on the other, to make the technology more successful and beneficial for Burkina Faso by co-sharing the technology. A leading cotton researcher states that:

> [The] America conventional variety wasn't appropriate in Burkina […]. Thus the discussion ends up at the combination of the gene to the local variety which is meant to be more productive. For this reason, the agreement was to introduce the gene into the local variety (Interview#53).

This was also an opportunity for a shared partnership. The SOFITEX director confirms this when he summarised that: "If we have to accept it [Bt cotton], it should be our local variety that we know is good. So if one day it doesn't work, we just get back to it without any big trouble" (Tiendrebeogo, 2006:4801). Civil society actors had been very critical of this issue of dependency that biotechnology cotton could provoke. Nacoulma (2011) underlines that Burkina farmers, by accepting the technology, could lock themselves into a vicious circle. It was therefore agreed that the gene would be introduced in Burkina Faso's local variety. This shows the extent to which the technology was being shaped by the Burkina Faso context.

Moreover, it promotes a collaborative agreement between Burkina Faso and Monsanto in order to share technology's benefits and reduce the dependency issue. Therefore, the gene from Monsanto was used in combination with the cotton seeds of cotton of Burkina Faso to make the Bt seed for distribution according to location. As an example of how this has worked in practice, the variety of seed used in the central region may be different from the one used in the west of the country.

However, there was a need to do trials on the effectiveness of the local variety in which Bt genes are inserted, and which required the contribution of local researchers.

Therefore, the local researchers, in collaboration with Monsanto used two experimental stations to examine the effectiveness of Bt cotton (CNRST, 2007). The conventional research system was not appropriate for biotechnology cotton. Indeed, before getting to trials, researchers needed the appropriate skills, abilities and knowledge of modern biotechnology in order to do the research. This presupposed a need for training in biotechnology research for local researchers. Monsanto included this training in its strategy and a few researchers received training at Monsanto's institute in the America for this purpose (Traore, 2011).

Finally, civil society actors, researchers and those industries with relevant ministries emphasized the need for a national regulatory framework which seems to fit in with Monsanto's plan. The company stated that this was the first condition it needed: the establishment of national rule. The interest of Burkina Faso in Bt cotton was a reason to go back to the Cartagena Protocol in order to establish some rules and regulations at the national level because of the specificity of the technology. The ANVAR director states that:

> If people think that Bt cotton came here [Burkina Faso] hazardously, [it] is to see [only] a bit of the story. I participated in Cartagena Protocol processes. We started to think, to make an international protocol where the signatories are going to talk the same language. If you want to bring GM, you need to be prepared and adopt national rules based on that Protocol (Interview#1).

The countries who were signatories to the Protocol had shown their willingness to take legal action regarding the new biotechnology in terms of use, transport and GM manipulation. It was high time for Burkina Faso to prepare to control GM movement through the country's borders.

> Many people and structures were optimistic about the GM initiative in Burkina Faso and wished that legislative and regulative rules could be settled to prevent risks and for the capacity building of biotechnology that is promoted by the Cartagena Protocol (Zangre and Massimbo, 2002:15).

Burkina Faso adopted the Cartagena Protocol, which arose from a situation of insecurity, in September 2003. Monsanto stated that its strategy "consists only in working with countries which have their rules on bio-security" (Burkina Biotech Association, 27: 2008). As a result of that the idea of bio-security was welcomed by both teams (Monsanto and the relevant actors). Two years of work was needed by researchers, relevant ministries and civil society actors to work out this issue. The rules relate to the environmental and human and animal health issues (Zangre and Mazimbo, 2002). A two-year project was initiated which was meant to culminate in a national regulatory framework based on the Cartagena Protocol. Rules were also adopted to respond to the need for the confinement of biotechnology products during the trials.

7.5.2. The Stabilisation in Bt cotton Adoption Process

There is therefore a relative stabilisation of the artefact in question – Bt cotton - as Monsanto managed to meet some requirements of the relevant social groups'. Callon (1986) calls this feedback of relationships which shape and align Monsanto with the relevant actors in Burkina Faso, "the triangle of interessement". The corners of this triangle are: Monsanto, Bt cotton and Burkina Faso.

➢ **Alliance Construction and the ST-Regime of Bt cotton**

In the case of Bt cotton implementation, the interessement was followed by a number of training sessions to acquire knowledge and skills in order to trial and test the technology's efficacy locally. As underlined by a researcher: "The capacity building was one important condition for this technology. Training first, for this we trained a certain number of researchers on the use of technology such as isolating the DNA and introducing it [to conventional Burkinabe cotton] (Interview#1). One can conclude that researchers, farmers, industries and the state were all enrolled but civil society actors remained very critical and reticent, making the process of stabilisation difficult to fulfil.

Monsanto's Bt cotton and Burkina Faso's conventional cotton would be trialled in order to test, on the one hand, the effectiveness of the technology and on the other, the behaviour of the gene in the Burkina Faso local variety. The *gene* coding for Bt toxin has been inserted into cotton as a *transgene*, causing it to produce this natural insecticide in its tissues. This first process involved researchers and Monsanto who had to lead these trials in direct collaboration with researchers and industries. It appears that Burkina Faso's conventional cotton had adapted to the Bt cotton gene. However, researchers needed to deal with other obstacles related to non-target, possibly beneficial insects which were not dangerous for the cotton plant, especially bees.

> When we did our first trial in Burkina Faso at the two research stations, it came out that Bt cotton fights against some specific insects very dangerous to the cotton plant, and our local variety is very well behaved with the gene. (Interview#59)

The first official trials received a number of visitors such as farmers and civil dignitaries at the national and international level who wanted to observe and attest to the technology's effectiveness (ISAAA, 2006). A farmer corroborates the efficacy of Bt cotton after a field visit: "We can attest that this new technology will really increase our productivity." (Interview#50). The National Agriculture and Environment Research Institute (INERA) conducted its first research trials in two locations: Farako-Ba in the west and Kouare in the east. To provide growers with more options for insect control and potentially greater productivity in the field, Burkina Faso began field trial evaluations with biotechnology cotton crops officially in 2003 (Ouedraogo, 2003). The objectives of the experiments and tests were to assess the effectiveness of the Bt cotton gene on the insects that infest fields, to analyse the financial issue of Bt technology for Burkinabe farmers and its impact on the environment. The research evaluated the effectiveness of Bollgard II in the climate and insect conditions specific to Burkina Faso. Bollgard II was tested in three different local varieties: FK37, FK290 and STAM 59 (Hema, 2011, Konate, 2011).

The concluding results from the trials[46] were:

- A yield increases averaging between 35% and 48%, in local varieties containing Bollgard II
- A reduction in the number of pesticide treatments per field from 6 to 2.
- A reduction in both pesticides used and number of treatments making it possible to save (€20) per hectare, a 62% cost reduction

[46] Data from papers presented by Hema and Konate during worshop on Biotechnologie et le Development Economic du Burkina Faso, Burkina Faso." Premiere Session extra-ordinaire, CES: 28 Mars- 19 Avril 2011.

- A practical proposition of 80% Bt against 20% conventional refuge zone was set to help fight against the insects' resistance.
- The coexistence of Bt cotton with neighbouring fields was proven

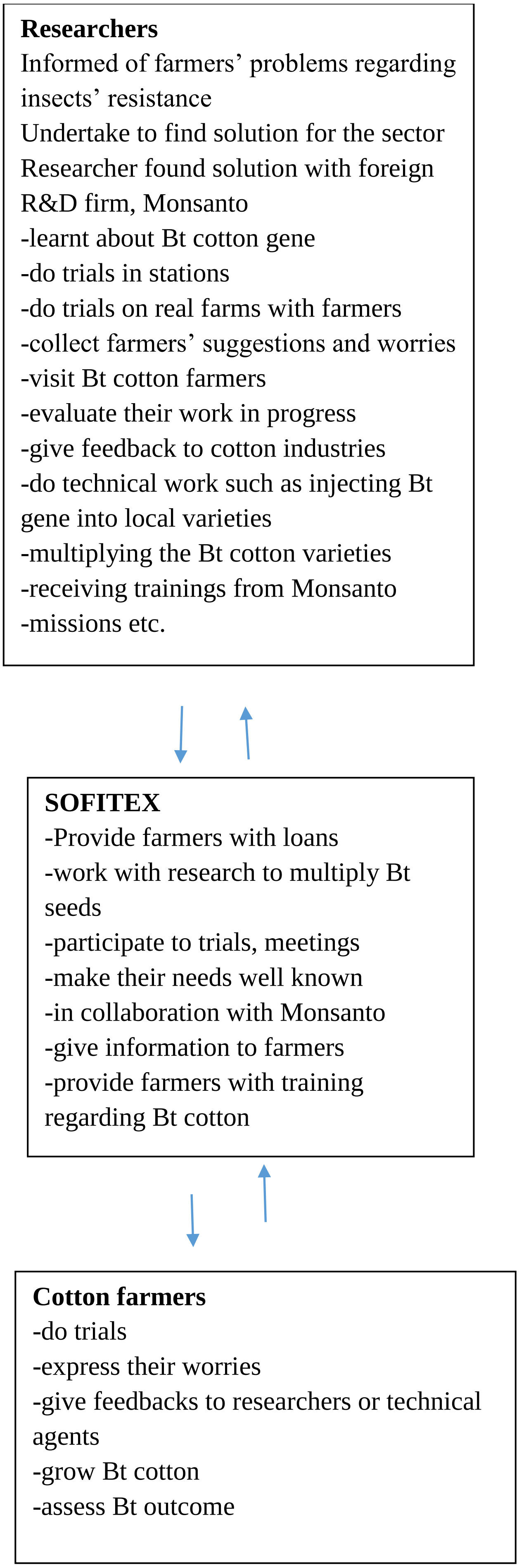
At this step, the actors, except civil society actors, were enrolled without any other resistance and they were apparently impressed by Monsanto's technology. Geels (2007) described such a long process as 'transformation' processes where feedback, modifications and conclusions were made. Most of the different allied actors saw the problem as solved, but, civil society actors remained immutable regarding its beliefs about the technology. This resistance within a key sector makes stabilization pending to some extent.

7.6. The Underlying Innovation Diffusion Approach in Bt Cotton Implementation

A close analysis of the way the different actors involved themselves in Bt cotton implementation reveals that there was no change in the way actors were networking to previous ST-Systems. The way different actors interacted in the implementation and diffusion of Bt cotton does not reflect the NIS diffusion tool. Instead it is similar to another approach which has been used in the cotton sector since the end of the 1980s. This diffusion approach is known as 'Training and Visits'. Therefore, the above description of the process of Bt cotton adoption and implementation in Burkina Faso appears to show that the underlying innovation diffusion approach which shapes the actors' behaviour in this process is the 'Training and Visits'.

This Training and Visits approach is described by Daniel Benor through the World Bank (Interview#17). In this approach, there is a possibility for information to travel between researchers, technical agents and farmers. In the present case of Bt cotton, what is evident is that farmers could directly exchange ideas, information, and anxieties with researchers and technical agents involved in Bt cotton growth. Researchers went down the farms and directly explained and assisted farmers on what to do. What was also specific in this process was that Monsanto, an international firm, the owner of the technology, was part of the network. It assisted research with training to increase understanding in order to support the other actors in the system. Both researchers and technical agents worked closely with farmers in the diffusion process of Bt cotton under the supervision of Monsanto. As can be seen, in this strategy, researchers were not doing research in laboratories on the technology. Instead, they were like technicians whose job was to multiply Bt seeds with local varieties and assist agents and farmers technically on Bt cotton growth through their visits and assistance at every step in the process. Such technical support is carried out by training and frequent visits to farms as in conventional cotton. As with the conventional cotton, with Bt cotton Innovation, farmers are in touch with researchers and technical agents.

Figure 12: Training and Visits approach in the implementation of Bt cotton in Burkina Faso

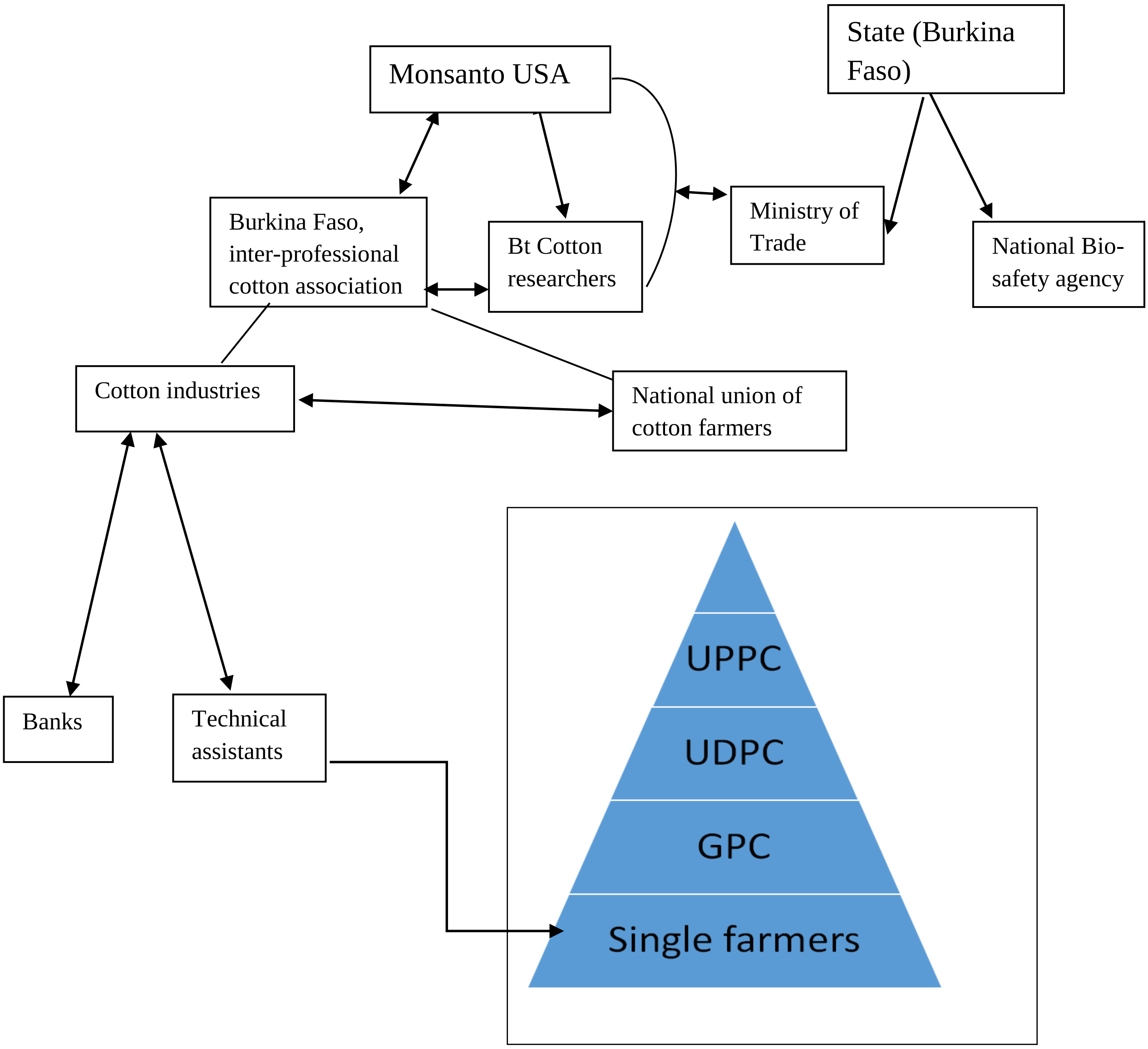


Source: processed by author

7.7. Assessing the Benefits from Bt cotton ST-Regime

The benefits derived by the key actors in the ST-Regime of Bt cotton in Burkina Faso are discussed here. These actors are: Monsanto, the owner of Bt cotton technology; farmers, who grow cotton, using Monsanto's Bt technological innovation through the sponsorship of the cotton companies; cotton companies which sponsor Bt cotton growth; researchers, (technicians), who are at the cross-roads of biotechnology cotton innovation adoption and development; and the state which is supposed to legislate and regulate the relationships between the different actors on the national cotton market. In practice a few actors obtained the right to express and represent the many silent actors in the process of Bt cotton adoption and the construction of its ST-System in Burkina Faso. In the case of Burkina Faso, network formation involved a few individuals, mainly researchers and farmers who played a representative role. When Monsanto negotiates with the national union of farmers' representatives and researchers, it considers this to be representative of all the farmers and all researchers. The green light for Bt cotton is not given by researchers and/or farmers, but by their representatives. They are those who allow the trials and welcome the new technology on behalf of the others

Figure 13: ST-System of Bt cotton



Source: Processed by author

The above figure 13 summarises the way involved actors are linked to one another in the ST-System of Bt cotton. This specific enrolment and network of actors helps to understand the benefits' distribution of the technology. In addition, the main change that occurred in the Bt system was safety regulation which matched the nature of the technology. This means that in Burkina Faso, the institutional regulation, if it does exist, is very limited and does not consider the extent to which an innovation could benefit both the owner and the adopter.

7.7.1. Monsanto's Benefits from Bt Cotton

Monsanto occupies a unique position in the ST-System of Bt cotton innovation because its leading position allows it to influence the ST-System. On the one hand, it is in an indirect relationship with the state, through the public cotton researchers of the Agricultural Research Institute (INERA) (Gerard, 2009). On the other hand, it is directly related to the Inter-Professional Cotton Association (AIC-B), an influential body for innovation decision making, and for economic strategies in the cotton sector (Zagre, 1994; CNRST, 2007; Gray, 2008). AIC-B is composed of the cotton industries union (APPROCO-B) and the National Union of Farmers (UNPC-B) (Gray, 2008). Monsanto's link with local cotton industries and researchers enables it to secure the quick diffusion of its technology down to the single cotton farmer (Gerard, 2009). In addition, in Burkina Faso, the lack of an innovation policy leaves room for informal negotiations between Monsanto and the state. Monsanto puts forward the view that its technology will benefit mainly poor farmers in BF. With its high quality seed production, it intends to alleviate poverty by giving farmers the opportunity to fight against poverty and hunger by using fewer resources. (James, 2002; 2009; ISAAA, 2006; Gross, 2007; Traore, 2011). In the light of this, one might conclude that Monsanto's aims have a strong philanthropic element.

However, the data in Burkina Faso suggests that the reality is more complicated. For instance, Monsanto technology is licensed at a high price (Shiva, 2001; 2003), which has introduced a major new and non-agricultural element to traditional cotton production in Burkina Faso (Benbrook et al., 2000; Tiendrebeogo, 2006). As stated by one interviewee farmer, “We have to buy it at a very high price because of Monsanto royalties as the owner.” (Interviewee#15).

Industry interviewees in general were not willing to provide data on the amount earned by Monsanto from its Bt cotton technology, but a local newspaper gave the following details:

> The negotiations have been done between Monsanto in collaboration with researchers […] where Burkina Faso is getting the most important profit. 60% for farmers, 28% for Monsanto, 12% for research and industries for farmers training” (Burkina Biotech Association, 2008:1).

This was contested by one of the interviewees:

> Monsanto, in any case is not going to lose, when they told you [you=me, the researcher] we are gaining, it is just a fake information, you can see by yourself …[If] this would have been true and all cotton farmers will be driving motorbikes” (Interviewee#26).

According to Monsanto spokesman Traore, the cost of the insecticide that farmers normally use needs to be included in the cost of the technology. One farmer gives here a very clear calculation on what Monsanto earns as the owner of the technology.

> For the seeds, it is charging the same price for Bollgard (the toxin) as in South Africa, that is to say \$60/25kg or 60x540=1296CFA. The cost for 1ha is 1296x36= 46556/ha. For the IPRs, it is charging the same taxes for Bollgard applied in US, \$99/ha, or 540x99=53460CFA/ha. [Then] Seeds cost and IPRs combined give 53460+46556=100016CFA/ha. In addition to the other expenses in inputs, the total amount is 199015+100016= 299031CFA/ha. As we can see only the seeds cost increase 1ha cotton growth at 98246CFA more than the conventional cotton (Interview#21).

These figures give a clear indication that the new technology is significantly more costly for the farmer, to the extent that it is largely out of reach of the poorest farmers, who were paraded in the early stages as one of the beneficiary groups of the new technology, while healthy profits for Monsanto look assured.

7.7.2. The Local Cotton Industries' Benefits from Bt cotton Innovation

The transition from the conventional cotton ST-System to the Bt cotton ST-System did not result in major changes to the pre-existing institutional arrangements (CNRST, 2007; Gray, 2008). The current private cotton companies inherited the public cotton industry whose institutional structure encompassed all of the country's cotton farmers. If the ownership changed with liberalisation, the integrated institutional structure remained, only it was now under the monopoly of private industries. The West region is dominated by SOFITEX with 80%, the East by SOCOMA with 12% and the Centre by Faso Cotton with 8% (CNRST, 2007). These industries have a monopoly on farmers' loans, insecticides and chemical input supply (Gray, 2008). A technical agent from SOFITEX confirms that: "Everything used in cotton cultivation: seeds, insecticides, chemical inputs etc. are lent by the industry to the farmers" (Interview#24). For instance:

> These small groups [of farmers] will evaluate their financial needs and they will get a loan from the cotton industry. This money will be distributed between them as well as chemical inputs and insecticides. The procedure of selling their cotton is an internal process agreed between them [UNPC-B (Farmers) and APPRO-B (industries)] (Interview#18).

Farmers' needs are evaluated with the support of technical assistants employed by the cotton companies for this purpose and are then reported to the companies which borrow the appropriate amount of money required for cotton production during the season for the input (cotton seeds, insecticides, and chemicals), so they act as sole input providers to farmers. Farmers have the obligation, based on their agreement with the cotton companies, to sell all their cotton to them. The loans (chemicals input, seeds, insecticides) are deducted from the income from the cotton that they sell to the companies at the harvest. Even if a farmer does not harvest anything because of lack of appropriate rain, he still has to pay the required amount, so whatever the harvest, the cotton industries do not lose their income stream. The field work revealed that the companies are also maximising profits by forbidding farmers to make any local use of the cotton. The agreement made with conventional cotton, to sell all their cotton including the seeds to the cotton companies, was sustained with Bt cotton arrival.

A former SOFITEX director, Celestin Tiendrebeogo, confirmed an additional reason for the cotton industries making great profits with Bt cotton, because they are spending less on imported insecticides. In his words:

> [Bt was] a real alternative, a very big change; this upcoming technology would save the huge amount of money spent annually on insecticides which is about 30 billion CFA; 20 billion for chemicals and 10 billion for insecticides. If SOFITEX is interested, it is because it constitutes an alternative for insect control. (Tiendrebeogo, 2006: 234)

In addition, another leading actor confirms that:

> We found it has many advantages, its quality, more white, it does not have any insects' attack. Visually, when one look at both, Bt cotton is more white. So this is one advantage for the companies on the world market with less seeds weight meaning more fibre and less weight. (Interview#12)

Hence, from the big producers' point of view, the new ST-System maintained their monopolistic advantages, while Bt cotton, the new artefact, added value through lower costs and a better, more saleable product.

7.7.3. Cotton Producers' Benefits from Bt cotton Innovation

In the ST-System of Bt cotton in Burkina Faso, the farmers represent the weakest link in terms of producer benefits, power and influence. The institutional arrangement of the national cotton market subordinates farmers to the cotton industries **(**Kaminski et al., 2009)**.** Although this is the general picture, some differences exist between large and small scale farmers. In general, the large scale farmers benefit from having representation at the different level of the national cotton farmers' organisations (Gray, 2008). The National Union of Farmers (UNPC-B) and the cotton industries together form the inter-professional association of Cotton Producers of Burkina Faso (AIC-B) (Interview#12). A general analysis of the benefits for the farmers is first undertaken, and then examined separately for large farmers representing 1% and small scale farmers representing 99%.

Historically, farmers are organised in GPC (village teams to receive credits, inputs loans etc. from the industries), then they are organised at departmental level to UDPC (Departmental Union of Cotton Producers) then UPPC (Provincial Union of Cotton Producers) and finally at the top UNPC-B (the National Union of Cotton Producers). Some of these representatives enjoy relationships which allow them to benefit from opportunities to travel and attend conferences, for example, rather than from the cotton itself. The analysis of the farmers' benefits includes two aspects: economic and health benefits.

First, although the benefits from the trials appear tangible and relevant, in reality they remain questionable for farmers. For instance, despite the benefits that farmers recognise from the reduction of insecticide use, which means energy and time saving in addition to less toxic exposure, the high price of Bt cotton seeds which is about 5 times more than that of conventional seeds ($55 for Bt as opposed to $12 for conventional) means that the saving from the reduced cost of insecticides is less than the money spent on Bt seeds. Below is a detailed picture drawn by an activist farmer in Burkina Faso during a conference:

> We are opposed to GMOs for several obvious reasons. The first reason is the catastrophic economic impact that the adoption of GMOs has had on farmers. The increase in the cost of the seed, from 1600 FCFA [24 Euros/34 USD] per

> hectare for conventional seeds last year to 54000 FCFA [82 Euros/115 USD] per hectare for GM seeds this year, is not accompanied by increasing yield as was promised. Worse, the Bt cotton produces fewer seeds than the conventional variety, and is thus two times lighter in weight for the same output of fibre. Thus, peasant farmers, who are paid by the weight of their harvest, are the losers, whereas SOFITEX is the winner.
>
> To take a concrete example: a truck full of conventional fibre weighed about 12 tons and generated 1.8 million FCFA [2748 euros] in revenue for the farmers. This same truck today, filled with the same amount of fibre, but from GM cotton, weighs 6 tons [50% less] and generates 900 000 FCFA [1374 euros, 50% less] for the farmers. This has caused significant financial losses for farmers during the first harvest of Bt cotton. Indebted farmers may have to sell their land, which will likely be bought by multinationals for monoculture export or bio-fuel. (Tiendrebeogo, 2011:12)

These outcomes signal a significant change at the agricultural, economic and social levels for small, local farmers, and not all of these changes will figure in cost-benefit calculations in relation to the introduction of Bt cotton.

Additionally, farmers and technical agents in Burkina Faso recognise that with Bt cotton, although they use less insecticides, they have to spend more on chemical input compared with conventional cotton. A farmers' representative said that "Bt cotton is more demanding, It is like a lady with twins, she needs to eat more in order to produce milk" (Interviewee#27). With respect to these realities, it is important to underline that the total cost of the chemical inputs used for Bt cotton is greater than for conventional cotton. This will make the total expense higher than what is claimed by proponents of Bt cotton. However, large scale farmers who are often members of UNPC-B appreciate Bt cotton because of benefits which appear unrelated to cotton growth. An activist has criticised the way UNPC-B farmers have advantages and privileges due to their position and sometimes do not defend the cotton farmers, but their individual interests, as demonstrates in the following quote:

> [W]hat is deplorable is the coalition between [UNPC-B and Cotton Industries] we always tell him [name] that this is not good, they are two different structures and he has to look at the research and judge good or bad and then make his own decision […] and they are in coalition. [name] is driving a special car, a cotton farmer, you can understand […] (Interview#29).

An article published by the Burkinabè daily paper SIDWAYA, n° 6923 (Audet, 2011) shows that farmers do not speak the same language and that the loyalty of the national union representatives towards the other farmers is questionable.

7.7.4. Cotton Researchers' Benefits from Bt cotton

A key actor among researchers who followed the process of Bt cotton introduction in Burkina Faso clarified the benefits for researchers in relation to this scientific project when he said:

> Capacity building was one important condition for this technology to be accepted. Training first: From this they trained a certain number of researchers for the use of the technology such as isolating the DNA and reintroducing it. Now what was missing is to include this aspect, and it is because I was fighting for this that I'm not in the circle! Yes, I was fighting for this capacity building, unfortunately those who were there and had the power of the research did not understand this and it wasn't well developed. Otherwise, normally at the end of the experimentation we need to have land, infrastructure, a laboratory with adequate equipment which will allow us to cut the DNA and stock it but

> people let this opportunity evaporate. Me, even the training of researchers by Monsanto, I found it very quiet (Interview#1)

After the event, then, of the introduction of Bt cotton as an innovative technology, many researchers seem not to have achieved any sustainable gain from Bt cotton at the time of writing up this thesis. These findings confirm earlier work by (Dowd-Uribe, 2011 and Dowd-Uribe and Schnurr, 2016). In contrast, some researchers who were collaborating with cotton industries for a long time in order to improve the quality of the cotton crop have been transformed into technicians by the arrival of Bt cotton. The benefits for researchers are more individual and limited to a few people who received training abroad at Monsanto's laboratory in USA. There is less profit for research institutes from a long term-perspective, and research institutes remain without appropriate tools for local biotechnology research. This reveals a lack of development of the independent research capacity in relation to cotton necessary for further research in the field of biotechnology.

Finally, at regional and international level, Burkina Faso became a key passage point for biotechnology in the sub-region (Zoungrana, 2011). First of all, the country has been shown to be the first to have rules and regulations in biotechnology with respect to GM in West Africa, therefore, the country is considered as being more experienced than other countries. Second, Burkina Faso became a source of knowledge and learning for other neighbouring countries (ibid). For instance, farmers from Mali came to Burkina Faso to witness biotechnology cotton cultivation in 2006 (ISAAA, 2006; 2012). Researchers, policy makers, and civil society actors from Europe and Africa have been visiting Burkina Faso because of its Bt cotton. In 2006, national and international visitors came along to see Bt cotton farms. For them, 'seeing is believing' (ISAAA, 2006). According to a State representative "Burkina Faso is very experienced and in advance compared to the neighbouring countries, in fact, by the time they realise that they are late, we [the country] are already far away" (Interview#31).

Another researcher highlighted that:

> ABNE [African Bio-safety Network of Expertise] in Burkina is a result of the adoption of Bt cotton making the country the first in West Africa. For them they can benefit from the country's experiences and expertise in biotechnology (Interview#34)

Burkina Faso's experience led to the NEPAD Bio-safety Network of Expertise being located in the country.

> When it was decided that it will be put in West Africa, automatically, the most technologically advanced centre has been chosen, in this part of Africa it is Burkina Faso, because it was and is the first country in the sub region which has grown and commercialised biotechnology products. It makes sense for the agency to be here (Interview#34).

7.8. Implication of Bt cotton adoption in Burkina Faso

The story of Bt cotton in Burkina Faso raises important questions about the quality of conventional cotton and the position that the country occupied on the world market with conventional cotton productivity and commercialisation. The exclusive "focus on pest mitigation contrasts sharply with the Francophone West African breeding programs, which spent decades integrating a broad spectrum of adaptability to growing conditions alongside multiple characteristics of fibre quality" (Dowd-Uribe and Schnurr (2016:10). In effect, by solving the problem of insect damage to Bt cotton, another problem was created, namely one where the high quality and yield of conventional cotton was compromised. Recent studies conducted by David L. Tschirley, Colin Poulton, and Patrick Labaste (2009) and Dowd-Uribe and Schnurr (2016) showed that one of the most important traits distinguishing cotton from West African from others is the 'quality' of its fibre and the fact that cotton is manually picked. These qualities had put the country among the top cotton producers in West Africa and in Africa more generally. Since the introduction of Bt cotton Burkina Faso is losing its leading role as one of top cotton producers because although Bt cotton requires less pesticides its fibres are shorter and less desirable than the long, uniform fibres of conventional cotton. Yields are also variable because conventional cotton has been designed for local weather conditions and is more drought resistant than Bt cotton.

As Dowd-Uribe and Schnurr report (2016: 6)

> Burkinabè cultivars [conventional cotton] are the product of decades of careful breeding that has resulted in premium cotton fibres, which are long, strong, and uniform. These traits are highly sought after for the production of high-end textiles and fetch a premium on the global market. The second reason why Burkinabè cotton fibre is of such high quality stems from it being hand-picked, which ensures that the fibre is free of other organic matter.

Such qualities have given Burkinabè cotton not only an international reputation but also and most importantly a premium price. As shown in graph 9, the price of conventional cotton was quite high between 2004 and 2005, when Bt cotton was being trialled in the country and despite issues related to insect damage, sold well on the international market compared to previous years.

The quality of Burkinabè conventional cotton is the result of a "very successful breeding programme that has spanned almost seventy years" (Dowd-Uribe and Schnurr, 2016:6). The "cultivation of breeding techniques began by ICRT which became part of the French agricultural research organization, CIRAD, in1984, and was eventually absorbed into national research institutes [such as the National Centre for Science and Technology (CNRST)]. The main goal of the ICRT-CIRAD breeding programme was to create cultivars that were well adapted to the growing conditions in West Africa" (Dowd-Uribe and Schnurr, 2016: 6-7). They clearly highlighted that between the "1970s and 2006/7, the average ginning ratio for Burkinabè cotton increased from 36 to 42 percent [which is] the distinguishing feature that made them more competitive in the global market" (Dowd-Uribe and Schnurr, 2016: 7). The percentage of Burkinabè cotton which has been classified as longer than this benchmark rose from 20 percent in 1995/6 to 80 percent of total cotton production in 2005/2006 (Tschirley, Poulton, and Labaste, 2009).

The arrival of Bt cotton seemed to solve the problem regarding insect damage, but created other problems such as the poorer quality of the fibre when compared with conventional cotton, which suggests that adopting Bt cotton could jeopardize Burkina Faso's advantage in the world cotton market.

7.9. Outcome of the Implementation and Interaction of Both (NIS and Bt Cotton) Projects in Burkina Faso

As demonstrated above, in the adoption of the Bt cotton innovation in the agricultural sector in Burkina Faso, the NIS diffusion tool was undermined by the involved actors through their behaviour in network building and their interaction. As a result of that the outcome for actors remains the same with Bt cotton as with conventional cotton. Indeed, despite the fact that Bt cotton was a new technology in the sector, the system in place remained the old conventional cotton system with the same behaviour and inequality in the distribution of benefits. The following statement from an interviewee explains this fact. For him, "[...] As you know the cotton sector has already been well organised and everything has been set, it is integrated through Training and Visits innovation diffusion strategies." (Interview#10). As will be shown below, this idea of 'well organised' is in fact apparent, because compared with the dynamics in other areas of agriculture the cotton sector is using an inefficient approach in relation to the advances in innovation diffusion approaches. In terms of returns, as for the conventional cotton, Bt cotton benefits were distributed among involved actors following their position in the system of actors; because, as described above, it is the 'Training and Visits' approach, put in place from the end of the 1980s, which shapes the outcome for Bt cotton. An officer at the Permanent Secretary for cotton growth in Burkina Faso has clearly stated the above claim. For him,

> You know, in fact, the case of cotton is particular. As a cash crop, the cotton sector has been consistent with its organisational framework. Such a framework which was adopted in the 1980s, remains dominant until now. You see the way farmers are organised, the way they [farmers] and the industries and the researchers work together is something which was built since that time and it still is now [...] (Interview#17)

As the findings show, the role of the state in such a system has not facilitated an equitable benefit distribution. If the technical environment had shifted, the human environment remained the same and it could not generate a better outcome for those who did not have a better position before, even with a new technology. With the exception of the regulatory framework adoption due to the fact that the technology (Bt cotton) calls for caution, the entire previous picture of actors' relationships remains the same. In conclusion the study has shown that as at policy level, the NIS diffusion tool has failed to be diffused at operational level.

Several different reasons can help explain this situation. First of all, the full implementation of the NIS diffusion tool at operational level did not come after its introduction at policy level. That is to say, in Burkina Faso, when the innovation approach left the niche level, it can either simultaneously or successively be adopted at both policy and operational levels. As the results have shown, when the NIS diffusion tool was looking for windows of opportunity at policy level, Training and Visits' approach was still being implemented at operational level with Bt cotton innovation. At the same time, in other areas in agriculture sector, it was the Multi-Actors Platform approach which was implemented. My research findings suggest that this latter evolved from the 'Training and Visits' approach, through 'farming system' approach. In effect, considering advances in innovation diffusion approach the cotton sector was stuck with traditional approaches.

The second reason of the failure of NIS policy tool diffusion at operational level, as is shown through the different shift in innovation approaches in Parts two, is that the NIS policy tool is itself an innovation; it is a diffusion tool which does not have any pre-existing national or local root. Such a diffusion tool completely broke with the old approaches to innovation diffusion implemented in Burkina Faso before the 2000s. As a result, its success would be a matter of completely uprooting the old successive diffusion approaches in order to settle on a totally new one. Such a reality has contributed to making the diffusion of the NIS policy tool unsuccessful, because of the lack of attention to the type of implementation actions needed to embed and develop it.

However, the Multi-Actor Platform, the improved form of ‘Training and Visits’ approach, contained elements of continuity from previous approaches, and was therefore more in line with the implementation activities taking place. It was an improvement over – rather than a direct replacement of old approaches to innovation diffusion already known in Burkina Faso, which gave it more credibility when compared to the NIS diffusion tool, which lacked history in Burkina Faso context. Additionally, the promoters of the Multi-Actor Platform approach were established in the agricultural sector, and had more secure funding. Analysis of the policy document shows that it was one considered as the tool for the implementation of the innovation.

The NIS policy tool attempted a diffusion strategy that goes from policy level to operational level, whereas the Multi-Actor Platform approach was established at operational level, and then took advantage of the position of its promoters at policy level to negotiate its adoption as a general framework for innovation diffusion in all sectors. Thus, the intended introduction of the NIS policy tool did not intersect as much as hoped with the original cotton innovation system and did not disrupt older research and training systems either.

7. 10. Conclusion

This Chapter has analysed the adoption process and implementation of Bt cotton in order to highlight the ways from which the Bt cotton innovation diffusion in Burkina Faso challenge the existing NIS diffusion tool. In other is has examine the underlying innovation diffusion approach which is used in such processes and the outcome derived from such diffusion approach and Bt cotton innovation. What emerges is that the NIS diffusion tool did not manage to displace the existing innovation diffusion approach in cotton sector in order to establish itself as the new approach which would increase productivity through new innovation implementation strategies (NIS policy tool). The 'Training and Visits' approach which has been used for more than two decades remains the most dominant approach with Bt cotton. Therefore, similarly to the case of integrated approach around cash crop in Chapter 4 (section 4.3.2), this approach builds strong links between technical agents, researchers and pilot farmers. Sometimes farmers' proposals are not well transmitted to researchers by the intermediary technical support agent. This aspect has seen some improvement with the Bt cotton innovation. The conclusion of all these has shown that it was not the NIS diffusion tool which informed Bt cotton implementation but instead an old approach to innovation which emerged at the end of the 1980s known as 'Training and Visits'.

Finally, at the time of the submission of this thesis, in early 2016, Bt cotton was abandoned by Burkina Faso. At that time, the country counted totally 7 years of commercialization and more than 10 years in Bt cotton implementation. The main reason found from published papers and local as well as international newspapers, is related to the quality of the fibre which is not competitive on the world market compare to the conventional one. According to Dowd-Uribe, and Schnurr, (2016), there is a decline concerning the length of the cotton fiber which “has undermined the reputation of Burkinabè cotton and cut into its value on the international market. When coupled with the decline in overall lint due to the lower ginning ratio, the inferior quality characteristics of the Bt cultivars have compromised the economic position of Burkinabè cotton companies.” (Dowd-Uribe, and Schnurr, 2016: Online). Burkina Faso which was spearheading of transgenic cotton in West Africa has decided to return this year to the conventional cotton. In addition, local news also revealed that the industry is suing Monsanto ($84 million) for compensation toward lost and damage caused by its technology. However, to my point of view the technical aspect of this reversal may not be actually the fundamental reason that has led Burkina Faso to abandon Bt cotton because, the adoption of the Bt cotton was not actually technical; as the data from Chapter 6 can show. Indeed, there was a functional conventional cotton system and the outcome in terms of productivity and economic gain were steady before Bt cotton (Chapter 6). It appears to me that the reason for the suspension of Bt cotton could be political instead of technical. Recent intervention of policy makers on the matter reveals that Burkina Faso hasn’t abandon the Bt cotton; instead, it ***suspended*** its growth for the time being in order to push further the reflexion through research, said the SOFITEX director early this year in local newspapers. Thus, this current trend on cotton growth in Burkina Faso remains very interesting and open up new research paths to investigate.

Chapter 8: General Conclusion

Policy makers around the world are pressed, in the context of knowledge-centred development policy, to look for the best tools for knowledge-oriented development strategies, as part of a strategy to bring benefits to the majority of the population. This is true for less-developed countries as much as it is for more economically developed countries. Over time, the NIS policy tool has gained popularity in policy circles. However, only a few studies have examined the diffusion of the NIS as a policy tool. This thesis is among the first to have looked at it in the context of an African country.

The thesis argued that changes to the policy framework for innovation diffusion in Burkina Faso were poorly implemented, resulting in a failure to achieve key goals in relation to technological developments in the cotton sector, and also failed to bring about significant improvements for the majority of the people involved with and reliant on the cotton industry for their livelihood. In order to establish the efficacy of innovation diffusion policy, two projects were investigated - the NIS inspired policy framework; and the Bt cotton innovation system – in order to assess how and to what extent they facilitated development in Burkina Faso at both strategic policy and operational levels. In particular it set the aim to:

- investigate the introduction, development and implementation of a National Innovation Systems (NIS) for innovation diffusion in Burkina Faso,
- demonstrate the application of the NIS with particular reference to the cotton industry, prior to 2003,

- investigate the introduction of Bt cotton, as a case study of an attempt to address the shortcomings of the existing innovation system, and innovate it.

- evaluate the outcome of the implementation and interaction of both projects in Burkina Faso

The findings established that the implementation of the NIS policy for innovation diffusion for socio-economic development in Burkina Faso was shaped by local actors competing for control of financial resources and power positions. The new tool also had to compete with older, more familiar tools. In the end, it failed to bring about the expected improvements in policy design and practice at sectoral level, with negative consequences for the expected benefits for those most in need of assistance in that sector.

The thesis takes Burkina Faso and its cotton industry as a case study to investigate the implementation of the NIS as a policy tool. Policy makers in Burkina Faso saw the NIS policy tool as an opportunity to improve living conditions in their country. In 2006, a project was developed by both the FRSIT (representing the government) and the IRDC with the aim to introduce the NIS as a policy tool in government practice in order to improve what this thesis refers to as the existing NIS of the country. As demonstrated, methodologically, the study of the introduction of the NIS as a policy tool cannot be limited to the investigation of its diffusion at the strategic level. One also needs to take into account the appropriation of such a policy tool at the operational level. From this perspective, it was therefore important, regardless of the state of the diffusion of the NIS policy tool at strategic level, to study its diffusion at operational level, which in this case is the agricultural sector in general and the cultivation of Bt cotton in particular. These two levels shared the same niche, namely the Forum for Scientific Research and Technological Innovation, (FRSIT), the place within which the NIS policy tool was tried out and from which it was diffused.

Based on a broader definition of technology that covers social technologies, this thesis used the ST-Systems analytical concept to examine the diffusion (or not) of the NIS. This conceptual framework was operationalized through a qualitative approach involving ethnographic methods for the data collection and analysis. This thesis found that the introduction of the NIS as an innovation diffusion tool did not manage to create a new and sufficiently favorable socio-technical system capable of improving the living conditions of the population in Burkina Faso. These findings emerged from a detailed study of the country-specific process of the appropriation of the NIS at both the strategic policy design level and the operational level through the case of Bt cotton innovation system. Based on a broader definition of technology that covers social technologies, this thesis used the ST-Systems analytical concept to examine the diffusion (or not) of the NIS. This conceptual framework was operationalized through a qualitative approach involving ethnographic methods for the data collection and analysis.

8.1. Policy level

As shown in Chapter 5, the full implementation of the NIS did not happen at policy level. One key aspect which hindered such institutionalization was the fact that conflicts between researchers from CNRST and Universities resulted in institutional changes and the removal of the NIS policy tool promoters from their posts within the system. When considering the content of the National Science and Innovation policy, there is little evidence to support the claim that the NIS tool was used by policy makers in the design of policies. Although the creation of the Ministry of Scientific Research and Innovation on the 16th of January 2011 is a result of significant changes at institutional level following the NIS policy tool adoption, the text in the ministry policy documents indicate that the NIS tool for innovation diffusion has not informed the policy design. One explanation of this failure is the exclusion from FRIST of the national team at FRSIT, the members of which had been involved in the learning processes for the transfer of the NIS policy tool to Burkina Faso. They would have had policy proposals based on the NIS policy tool. However, their exclusion was a contributory factor leading to the tool not being adopted. Indeed, the new actors who took over the lead of the Ministry wanted to promote another well-funded approach - known as innovation platform - that they were implementing even before they joined the ministry. This conflict is a continuation of a deeper long-standing conflict between university and research centre scholars. It was an important factor in shaping the NIS policy tool adoption in Burkina Faso. Consequently, the NIS initially adopted as a tool for innovation diffusion in Burkina Faso was not diffused as it should have been, as individual interests took over the country's socio-economic development.

To understand such processes at the operational level, there was a need to go back to the policy level and see how the NIS policy tool was adopted. Indeed, the findings show that the NIS policy tool has not been fully institutionalized at policy level. Its diffusion at policy level had failed. In the diffusion process, the national team's strategy was to involve policy makers. These policy makers were therefore invited to take part in a range of different activities in order to encourage them to become interested in the policy tool and then play an active role in the diffusion network process, in contrast with previous processes involving the diffusion of innovation policy, where policy makers had played a passive role. The national team at FRSIT was aware of this necessity to create conditions for the active involvement of the relevant actors, as a result of their own learning process at niche level. Policy makers were key components. Such involvement aimed to sensitize decision makers to take appropriate decisions and to facilitate the flow of knowledge between the different actors involved in innovation. Within this framework, policy makers were considered as the creators of a favorable social and political context in which actors could network appropriately in a formal way (Geels and Kemp, 2007). Therefore, the national team strategy was to involve them in order to encourage their collaboration with the other relevant actors.

The outcome of the diffusion process at policy level was the creation, on the 16th of January 2011, of the Ministry of Scientific Research and Innovation (MRSI). The focus on this new dimension of 'innovation' became important following the activities around the NIS tool at niche level by the national team at FRSIT. The creation of the new Ministry is intrinsically linked to the CNRST's aim to give more visibility to research and innovation activities in Burkina Faso and to optimize the results of scientific research and inventions. As demonstrated in Chapter 5 (section, 5.3.3) there is a clear similarity between the objectives of FRSIT, which played the role of niche for the NIS policy tool, and the MRSI. The influence of such a tool on the organizational design of the Ministry (MRSI) is clear. The FRSIT's function was being generalized in the MRSI to make a national framework for innovation and research

When considering the content of the National Science and Innovation policy, there is little evidence to support the claim that the NIS has been used by policy makers in the design of policies, although significant changes in the vocabulary (policy languages or texts) could give the impression that the NIS policy tool has informed the policy design. The presence of key words such as ‘innovation’, ‘national research and innovation systems’, ‘innovation systems’, ‘science and innovation policy’, ‘intellectual property rights’, undoubtedly contrasts with wording in previous policy documents on science policy and innovation approaches.

However, on further examination, it is hard to reconstruct a complete policy framework which reflects the underlying assumptions of the NIS framework. As the analysis in Chapter 5 attests, the diffusion of the NIS policy tool has failed.

This failure to adopt the NIS as a policy tool for innovation diffusion is the result of complex factors. One of them is linked to a lack of understanding by the actors who took the lead in the diffusion process at the MRSI. They excluded the national team at FRSIT which had been involved in the learning processes for the transfer of the NIS policy tool in Burkina Faso. This national team would have had policy proposals based on the NIS framework. In contrast, the new actors who took over the lead did not really understand fully the idea behind the NIS policy tool that needed to be promoted, so they were unable to carry out their mission successfully. This limited knowledge of this policy tool by the new actors in the ministry (MRSI) was an important factor in shaping the NIS adoption as a policy tool in Burkina Faso.

Another factor which hindered the full implementation of the NIS tool at policy level was financial. This appears to be more or less the case for all sectors in the country. A relevant factor was that the country had been for a long time – and still is – under an authoritarian regime, and had been strongly dependent on external financial support from international institutions. The dependence of the State on external funding for the implementation of its development policies constituted an obstacle for previous approaches as it did for the NIS policy tool for innovation diffusion. When the funding for the NIS ended in 2011, a competing approach named 'Multi-Actor Platform approach for innovation', which emerged around the same time as the NIS tool in Burkina Faso, was thriving. This competing approach (Multi-Actor Platform) was and is regularly well-funded by international agencies such as FARA; whereas the NIS funding from IDRC finished.

Another factor which helps to explain the displacement of the NIS tool in favour of the Multi-Actor Platform -at policy level- is that in contrast to the NIS tool, the Multi-Actor Platform diffusion approach has been adopted and directly implemented at an operational level by the Agricultural and Environmental Research Institute (INERA). Such an approach was therefore well known by the new actors at the Ministry who were members of this Research Institute before the creation of the Ministry. The approach focused more on the agricultural sector.

8.2. Operational Level

Several different reasons can help to explain the failure of the diffusion of the NIS tool for innovation diffusion at operational level. First of all, the full implementation of the

NIS policy tool for innovation diffusion at operational level did not happen after the failure to adopt it at policy level. That is to say, in Burkina Faso, when the innovation approach left the niche level, it could either simultaneously or successively be adopted at both policy and operational levels. As the results have shown, when the NIS tool was looking for windows of opportunity at policy level the Training and Visits approach was still being implemented at the operational level with Bt cotton innovation.

The second reason of the failure of the diffusion of the NIS tool at the operational level, as is shown through the different shift in innovation approaches in Parts two and three, is that the NIS tool is itself an innovation; it is an approach which does not have any pre-existing national or local root. Such a framework completely broke with the old approaches to innovation implemented in Burkina Faso before the 2000s. As a result, its success would be a matter of completely uprooting the old successive approaches in order to settle on a totally new one. Such a reality has contributed to making the diffusion of the NIS tool for innovation diffusion unsuccessful, because of the lack of attention to the type of implementation actions needed to embed and develop this approach.

By focusing on the agricultural sector, the Multi-Actor Platform diffusion approach not only took advantage of the regular funding of the sector, but also benefited from an already established socio-technical network. The NIS tool funding, which was fully supported by the IDRC, ended in 2011; a key time when finances were needed to enable its adopters and experimenters to take control of the newly created MRSI. In doing so, these adopters and experimenters of the NIS tool would have built appropriate innovation policies in line with the NIS framework. Furthermore, as explained in Chapter 5 (section 5.3.4), in Burkina Faso many development projects do not have sustainable follow-up support at the end of the funding period. Most of the time, when a funding grant finishes, its supported project ends without further action being taken by the national actors to keep it alive. To an extent this is what happened with the NIS policy tool. Nevertheless, such a tool would not have survived even if funding had not ceased. Continued funding would have helped, but that alone would have been insufficient to ensure the widespread diffusion and use of the NIS tool. Finally, the long standing conflict between the public universities (University of Ouagadougou and its branches) and the public research centre (CNRST with its four institutes), whose members are key actors in the design and implementation of development policies, was another crucial problem which impacted on the full diffusion of the NIS tool. Such a conflict, detailed in Chapter 5 (section 5.3.4), militated against the NIS policy tool diffusion. Instead it helped the Multi-Actor Platform to become the most widely used approach in the agriculture sector. In fact, actors involved in the Multi-Actor Platform were exclusively from the CNRST and were also leaders of the new MRSI which was created exclusively for researchers. FRSIT which was a niche for both researchers and teaching researchers lost its power as permanent secretary to become a small department of the MRSI. The NIS policy tool initial actors were thus excluded from vital policy making circles.

8.3. Some reflection on the NIS Tool compare to Previous Diffusion Approaches

From this study one of the possible questions would be weather technically the NIS tool for innovation diffusion is capable of being more effective than the previous ones.

Based on the above findings, I am inclined to support an affirmative view for several reasons:

Indeed, I believe that potentially, the NIS tool is more comprehensive for the diffusion of innovation when compared to the integrated approach around cash crops, Training and Visits, and even to the more recently used approaches such as Farming Systems and Multi-Actor Platform. Drawing from Chapters 2, 3, 4 and 5, the following compares the different diffusion approaches.

Table 15: comparison of previous and existing innovation diffusion approaches with NIS tool

	Components			Potential for participation	Wealth creation from Knowledge[47]					
Innovation diffusion approaches	**Government (role)**	**University (role)**	**Firms (role)**		1	**2**	**3**	**4**	**5**	**6**
Top-Down			X	No participation		X				
Top-Down Bottom-Up			X	Limited participation		X				

[47] 1-Enterpreneurs trying to create new start-up businesses that deploy knowledge in new ways;
2- Managers in established businesses trying to improve productivity through the effective application of new knowledge and who are also concerned with the 're-invention' of the business through a form of corporate entrepreneurship;
3-R&D managers in the public and private sectors trying to improve the take-up of knowledge created in their groups;
4-Knowledge intensive business service providers trying to build a business through enabling connections and flows within the knowledge system;

5-Governement policy agents at local, regional and national level charged with improving the efficiency and effectiveness of the innovation system;
6-Supply chain 'owners' concerned to upgrade the system-level efficiency and effectiveness of their networks through innovation.

Farming Systems			X	Participative		X		X		
Multi-Actor Platform			X	Participative		X	X	X		X
National Innovation Systems	**X**	**X**	**X**	Participatory methods not adapted to all settings in developing countries		**X**	**X**	**X**	**X**	**X**

‘X’ means that the element exists

Source: Processed by author from Chapters 2, 3, 4 and 5.

More specifically, as it appears on the above table, the NIS is an innovation diffusion tool in which the role of the government is prominently stated and tested. Many of the innovation system scholars made the role of government in innovation dynamics explicit (Freeman, 1995). For instance, as demonstrated in Chapter 2, the acquisition of technology, its use and diffusion involve the government whose role in the system is essential. It is clearly set out there that through policymakers, government plays a key role by making choices which inform strategies at national level (Freeman, 1987). The government is considered as a lead actor which influences through policy and institutional design. In addition, governance influences Foreign Direct Investment (FDI) because, "despite their limited size, FDI inflows have had a positive impact, in as much as they generated employment in the formal sector and generated local value-addition" (United Nations, 2009:2). On the other hand, such a flow is supported within the framework of government Intellectual Property Right (IPR) regulation; by designing the IPR system for the sake of business and government direct scientific research such as financing universities, supporting business R&D, "the Government has a responsibility to contribute to the formation of the human and social capital needed to evaluate, choose, implement and modify foreign technologies" (Feinson, 2003: 23).

The commitment of the government to provide actors with such a context is thus required in order to produce a favourable social and political context for the networking of firms and knowledge producers. None of the previous approaches has made this explicit as is done in the NIS policy tool. The wording in the Farming Systems and Multi-Actor Platform approaches should not mislead one as to their consideration of this macro level aspect. In neither case is there a comparable documentation of the working of the State within the system as there is in the NIS framework. An application of the NIS tool for innovation diffusion would have at least resulted in the creation of institutions and other resources for which the government is the best actor. While the Multi-Actor Platform approach is mentioned in Burkina Faso innovation policy, the reality is that this approach unlike the NIS tool has not tested and approved the standards and mechanisms of the best ways for government intervention in the innovation system.

An application of the NIS would have at least sensitized the government and other relevant actors to the need for building research infrastructures; because the NIS policy tool for innovation diffusion has demonstrated that domestic resources are key to sustainable successful innovation diffusion.

The only aspect around which the NIS tool for innovation diffusion and the previous approaches meet is the instrumental role of industry as the user of research results. Enterprises/firms/industries are all considered as business actors who are the users of the knowledge created by the knowledge producers, from universities and research centres (OECD, 1999). As demonstrated by the OECD (1999), business or industry does not function alone because government as well as university are all integral parts of the system in the innovation process. As for the firms/industries, they are considered as business actors: their role is to conduct and support R&D for the purpose of developing products for the commercialization. They are those who launch the different innovative products and exploit the new scientific discoveries (OECD, 1999). Even at this industrial level, the NIS policy tool has the potential to do more than the previous approaches. These latter have been developed for economic purposes which predate the establishment of the NIS tool; they have not been developed mainly for the knowledge economy. The NIS tool to diffuse innovation has not only the potential to support manufacturing, but more importantly to generate a whole industry around the creation of wealth from knowledge. This weakness of the previous approaches is particularly apparent regarding their potential to promote the development of a knowledge economy as the NIS policy tool is potentially designed to do.

However, due to the local realities where there is a huge inequality between the key actors involved in the system in terms of knowledge, skills and even the poverty of the broader social context, it is important to adapt the NIS's communication channels. In fact, the NIS could benefit from the other diffusion approaches' communication channels. From this perspective, the NIS tool could learn from the communication strategies of previous innovation approaches. For instance, the way in previous approaches where participation helped to bring actors with shared interests together for a successful innovation diffusion among mainly rural actors in Burkina Faso as shown in previous approaches could be exploited while using the NIS policy tool for innovation diffusion, should it be generalised in Burkina Faso.

In a favourable socio-technical context, the NIS policy tool could generate better outcomes if it was widely understood and diffused with appropriate communication strategies from previous approaches. Nevertheless, one should still keep in mind that the NIS tool's outcome depends on the socio-technical environment of its implementation. In this respect, the weaknesses of the previous approaches as in the shaping of innovation outcomes in the interest of the weaker actors of the system could also occur with the NIS tool. The reason is the socio-technically embedded character of any technology. For instance, if innovation is to bring welfare to the majority, it needs a democratic society with a strong and well informed civil society to play a role of countervailing power against exploitation and bad governance.

8.4. Contributions to the Literature

A number of studies on the diffusion of NIS have focused on policy design. This thesis is not only the first to have looked at this in an African context, but also it goes further by empirically investigating its implementation as an innovation diffusion tool in Bt cotton adoption including the evaluation of its outcome. Despite its relative advantage compared to previous approaches, the NIS tool has failed to displace the old innovation diffusion approach (training and visits) in Bt cotton implementation. As such, its role in facilitating socio-economic development in Burkina Faso cannot be substantiated. Findings show how these two innovation projects, NIS and the Bt cotton, proved to be incompatible and incapable of enhancing Burkina Faso’s innovation policy. Rather than using and building on each other’s strengths, the two projects were prevented from inspiring each other, largely as a result of the way that the socio-technical and organisational systems in place in Burkina Faso were set up and operated. This suggests a key lesson for developing countries such as Burkina Faso in the context of the knowledge-centred development policy, that technological innovation is not in itself or necessarily a panacea for development problems. Any debate about the relationship between innovation and development has to take into account the pattern of socio-technical arrangements within which new technologies are to be deployed. This includes social ‘technologies’ such as the NIS policy tool.

Second, this thesis is among the first to have studied empirically the transfer processes of the NIS framework as an innovation diffusion tool in an African country through a case study. Up to now, there have been very few empirical studies of the kind which have been reviewed in this thesis. Some studies were undertaken by Cambrosio, Limoges and Pronovost (1990) who focused on the way the NIS framework has been used to develop science policy implementation in Quebec, Canada, while Albert and Caberge (2007) were also interested in the fact that the NIS framework was embedded in science policy in Quebec, Canada. Sharif (2009) explores the ways in which the NIS framework has shaped innovation policy making in Hong-Kong. Other studies investigate the use of the NIS framework as an "analytical tool" in African countries. For instance, Ecuru et al., (2012) looked at the NIS as an analytical tool in Uganda, a similar focus to that found in the collected *Putting Africa first: the making of African innovation systems* by Mammo Muchie and collaborators (Muchie et al. 2003). However, all these empirical studies have only looked the NIS concept at policy strategic level. This thesis went beyond to investigate its appropriation at operational level in the agricultural sector with a focus on the introduction of Bt cotton. It is also important to note that others PhD studies were conducted on Bt cotton innovation in Burkina Faso. For instance, Renaudin (2011) compares Bt cotton yield and incomes with that of the conventional one by looking at the outcomes of Bt cotton in relation to its technical itinerary that farmers do not follow. In addition, Dowd-Uribe (2011) in his PhD thesis looked at the agricultural reforms and its outcomes while studying Bt cotton in Burkina Faso. This present study is to date unique because it focuses more specifically on evaluating the Bt cotton diffusion approach which has played a very key role in its outcome.

Another theoretical contribution relates to the use in this thesis of the Socio-Technical Systems analytical framework promoted by Frank Geels to study a social technology of the kind of the NIS policy tool. The few studies which looked at the NIS framework as a policy tool have also used other STS approaches such the Social Construction of Technology (SCOT) (Sharif, 2009). It has been demonstrated that SCOT is a useful framework for the study of the National Innovation Systems as a policy tool, and Actor Network Theory (ANT) has also been shown to have some applicability. Sharif (2009) considered that Law's (1992) and Callon's (1986) analyses are also applicable to the innovation systems development tool because they agree that ANT as a theoretical lens is used to examine the socio-technical means through which agreements are reached during standard making and adoption. In the same way, Cambrosio et al (1990) have used ANT to study the science policy episodes. However, this thesis could not use these frameworks because of their unsatisfactory integration of the outcomes component in technology diffusion. As a result, it uses the ST-Systems analytical concept which not only looked at the processes but also the acknowledge the outcome derived from such a process.

Finally, another contribution relates to the fact that this thesis is one of the first which has studied the implementation of the NIS tool through the case of Bt cotton. Yet, from an STS perspective, the diffusion approach used to implement innovations such as Bt cotton is important if the innovations are to be successful. As this thesis has shown, the unequal distribution of Bt cotton benefit is intrinsically linked to the approach used to diffused it.

8.5. Research Limitations

The limitations of this research are related to the fact that this thesis is not restricted to the choice of Bt cotton innovation as an innovation for socio-economic development as it stands; instead, Bt cotton here only serves to highlight the underlying innovation diffusion approach which is used for Bt cotton implementation in the cotton sector. Thus, I would like to state that my exclusive intention here is neither to enter into the controversy surrounding Bt technology in particular nor the fierce debate around GM crops in general, nor, to propose the NIS tool as a best innovation diffusion tool for Burkina Faso; but instead, my exclusive concern was to investigate the organisational system, which was put in place to implement the NIS as a policy tool for innovation diffusion for human development purposes.

Possible future research in relation to my thesis would initially focus on assessing more in-depth the weaknesses of the previous and existing approaches to innovation. I would like to investigate the communication methods used in these approaches in order to improve them and see how they can be used to improve the weaknesses of the NIS tool for innovation diffusion (initially conceived for developed countries) in context of Burkina Faso. At the same time, the study of these participative methods will shed light on how they can be improved and integrated.

Second I am planning to conduct some studies in relation to the strengths of the NIS policy tool for innovation diffusion in comparison to the weaknesses of the other previous approaches. In doing so, I would like to fully prepare myself to build a clear case in support of the NIS policy tool to inform policy makers when there is a more informed debate about the choice of an innovation diffusion tool. I am convinced that the NIS tool for innovation diffusion is going to make a comeback in the near future with regards to the current trend at policy level in Burkina Faso.

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Appendix 1

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Appendix 2

Interview between 1 to 2 hours

Code of the person interviewed	Role and Institutional affiliation at the time of the interview	Date and location of interview	Consent type
Interview # 1	Researcher at CNRST	20/03/2011	Written
Interview # 2	MRSI Policy maker	20/03/2011	Written
Interview # 3	Researcher at University	22/03/2011	Written
Interview # 4	Civil society	23/03/2011	Written
Interview # 5	Small farmer	23/03/2011	Oral
Interview # 6	Small farmer	23/03/2011	Oral
Interview # 7	Researcher CNRST	24/03/2011	Written
Interview # 8	Big farmer	24/03/2011	Written
Interview # 9	A political official in parliament	26/03/2011	Written
Interview # 10	Policy maker	26/03/2011	Written
Interview # 11	IDRC adviser	26/03/2011	Written
Interview # 12	Big farmer	27/03/2011	Oral
Interview # 13	Policy maker on project NIS	28/03/2011	Written
Interview # 14	Policy maker	28/03/2011	Written
Interview # 15	Small farmer	29/03/2011	Oral
Interview # 16	President adviser	30/03/2011	Written
Interview # 17	Researcher CNRST	1/04/2011	Written
Interview #	Small farmer	2/04/2011	Oral

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Interview # 19	Ministry advisor	2/04/2011	Written
Interview #20	Small farmer	3/04/2011	Oral
Interview # 21	Big farmer activist	3/04/2011	Written
Interview # 22	Ministry advisor	4/04/2011	Written
Interview # 23	Researcher at University	4/04/2011	Written
Interview # 24	Activist	4/04/2011	Oral
Interview # 25	Activist	4/04/2011	Written
Interview # 26	Small farmer activist	5/04/2011	Oral
Interview # 27	Small farmer	5/04/2011	Oral
Interview # 28	Researcher University	6/04/2011	Written
Interview # 29	Activist researcher	7/04/2011	Written
Interview # 30	Activist	8/04/2011	Oral
Interview # 31	State representative	9/04/2011	Written
Interview # 32	Policy maker parliament	10/04/2011	Written
Interview # 33	Small farmer	1 1/04/2011	Oral
Interview # 34	ABNE director	12/04/2011	Written
Interview # 35	Small farmer	20/04/2011	Oral
Interview # 36	Big farmer	20/04/2011	Written
Interview # 37	Small farmer	20/04/2011	Oral
Interview # 38	Small farmer	20/04/2011	Oral
Interview # 39	Researcher IDRC based in Burkina	21/04/2011	Written

Interview # 40	Small farmer	22/04/2011	Oral
Interview # 41	Cotton industry	23/04/2011	Written
Interview # 42	Researcher UEMOA	24/01/2011	Written
Interview # 43	Activist	24/04/2011	Written
Interview # 44	Cotton industry	25/04/2011	Written
Interview # 45	Activist cotton	26/04/2011	Written
Interview # 46	Small farmer	26/04/2011	Oral
Interview # 47	IDRC representative	27/04/2011	Oral
Interview # 48	Cotton industry	28/04/2011	Written
Interview # 49	Big farmer	5/05/2011	Written
Interview # 50	Small farmer	5/05/2011	Oral
Interview # 51	Big farmer	5/05/2011	Written
Interview # 52	Research University	10/11/2014	Written
Interview # 53	Researcher CNRST	10/11/2014	Written
Interview # 54	Researcher University	10/11/2014	Written
Interview # 55	Activist cotton	12/11/2014	Written
Interview # 56	Big farmer activist	26/11/2014	Oral
Interview # 57	Big farmer	26/11/2014	Written
Interview # 58	Civil Society Activist	29/11/2014	Written
Interview # 59	ANB	10/12/2015	Written
Interview # 60	Monsanto national representative	15/12/2015	Written

Short discussion 10-20mn (note taken)

Institutional affiliation and role	Role in NIS or Bt cotton adoption	Date of the meeting	Statement
Member of parliament	Passing laws on GMO	28/04/2011	None
Member of parliament	Passing laws on GMO	28/04/2011	None
Monsanto representative	Corporate interest	29/04/2011	None
Member of parliament	Passing laws on GMO	30/05/2011	None
ANB officer	Regulator of GMO	31/05/2011	None
ANB officer	Regulator of GMO	04/05/2011	None
UNPCB officer	Cotton farmers' organisation administrator	05/05/2011	None
Faso cotton officer	Corporate interest	06/05/2011	None
SOCOMA officer	Corporate interest	06/05/2011	None
SOFITEX officer	Corporate interest	07/05/2011	None
SOFITEX technical agent	Corporate interest	11/05/2011	None
Monsanto representative national level	Corporate interest	12/05/2011	None
Monsanto representative regional level	Corporate interest	14/05/2011	None

Appendix 3

Guide for interview questions

Farmers

The role of cotton in the past in Burkina Faso

economic

social, cultural/ family

length of your involvement time in cotton growth

justification and reasons for being cotton farmers

family, cultural or self-initiative

Actors involved in cotton growth with you in the past

Actors

Their function

Your relation with them

Before, during and after colonisation

Their linkages and collaborations with you at this time

Transitional period: from indigenous to BT cotton

Explanation: justification of any shifts or changes you have made

date of enrolment in this new technology

explain the process of your enrolment

Actors involved in BT cotton growth with you actors in contact with you (your collaborators, and possible partners)

type of collaborations and cooperation

collaboration's interests and advantages for you

actors not directly in contact with you. Their existence and role in BT cotton implementation is known

type of relationships between you and them

What do you think about your role and collaboration/cooperation with all the other actors in BT cotton implementation?

Changes with BT cotton growth

positives

negatives

in order to step outside this either/or approach, also ask what is interesting, i.e., neither a plus or a minus, but thought-provoking

7- Relationship with industries and researchers

relationship before

relationship now

impression on such a relationship

knowledge on the NIS

Scientists/researchers

On Bt cotton

Background information

research in indigenous cotton

start date

specific role

collaborators/partners (national and international level)

type of collaborations and interests/advantages

Transitional period: from indigenous to Bt cotton

Description and justification

date of enrolment

explain the process of this transition in your research with BT cotton

The other actors in BT cotton

actors directly in contact with you in your research process

other type of collaborations

reasons/interests

actors indirectly in contact with you

type of relationship between you and these other actors

regulation of Bt cotton

date of adoption

your view and comment about it

changes in research on Bt cotton

positives

negatives

5-Linkages and their mechanisms

Mechanisms

Objectives

Set up date

Initiators

Reasons/circumstances

Mode of coordination

Previous mechanisms

Reasons for changes in the mechanisms

Involved actors in the implementation of current mechanisms

Difficulties

Mode of resolution

Support from another actor in the network

Actor' reaction

On The NIS

FRSIT-CRDI's Project

Project development

Justification of project

Composition of project team

Organisation set up for project implementation in

Trainings based in BF

Content

Objectives

Trainers

Trainees

Training justification

Trainings which took place outside the country

Place/country of training

Institutions of training

Mode of knowledge of the institutions

Reason for choice of training institutions

Content of training

Objectives of training

Trainers

Trainees

Training justification

The initiators of training

7-Project implementation

Activities undertaken

Justification of implemented activities

Objectives of these activities

Involved actors

Justification of actors' selection

8-Project evolution to date

Project duration

Project's institutional affiliation

Lessons learnt from project

Appreciation of project's achievement

Project's contribution to policy formulation

Justification of achievement

Interaction between key actors in BF with UNIT-MERIT and CRDI's actors

Existence of other innovation approaches in BF

Content of the approaches,

9-Similarities and difference with regard to the NIS

10-At policy makers level

Existence of innovation policy

State of research

State of higher education

Existence of sectoral innovation policy

Agricultural higher education

11-System performance

Interview guide for Government officials and industrials

On Bt cotton

Background information

role in indigenous cotton growth and research

partners in indigenous cotton (national and international)

type of cooperation and partnership that you had during that period before Bt cotton, interests/ advantages

Transitional period: from indigenous to Bt cotton

date of enrolment

Description of the process of your involvement

reasons

Actors in Bt cotton

actors directly in contact with you in BT cotton implementation type of cooperation

reasons/ interests

actors indirectly in contact with you

type of relationship between you and these other actors

Regulation of Bt cotton

Period of adoption

reasons

changes with Bt cotton policies compare to indigenous cotton

positives

negatives

6-Linkages and their mechanisms

Mechanisms

Objectives

Set up date

Initiators

Reasons/circumstances

Mode of coordination

Previous mechanisms

Reasons for changes in the mechanisms

Involved actors in the implementation of current mechanisms

Difficulties

Mode of resolution

Support from another actor in the network

Actor' reaction

Interview guide for Activists/civil society NGO

Background information

research in indigenous cotton

start date

specific role

collaborators/partners (national and international level)

type of collaborations and interests/advantages

focus

Transitional period: from indigenous to Bt cotton

Description and justification

date of enrolment

explain the process of this transition in your research with BT cotton

The other actors in Bt cotton

actors directly in contact with you

other type of collaborations

reasons/interests

actors indirectly in contact with you

type of relationship between you and these other actors

regulation of Bt cotton

date of adoption

your view and comment about it

changes on BT cotton

positives

negatives

10-relationship with industry, cotton farmers and the State on the NIS project

FRSIT-CRDI's Project

Project development

Justification of project

Composition of project team

Organisation set up for project implementation in

Trainings based in BF

Content

Objectives

Trainers

Trainees

Training justification

Trainings which took place outside the country

Place/country of training

Institutions of training

Mode of knowledge of the institutions

Reason for choice of training institutions

Content of training

Objectives of training

Trainers

Trainees

Training justification

The initiators of training

Project implementation

Activities undertaken

Justification of implemented activities

Objectives of these activities

Involved actors

Justification of actors' selection

Project evolution to date

Project duration

Project's institutional affiliation

Lessons learnt from project

Appreciation of project's achievement

Project's contribution to policy formulation

Justification of achievement

Interaction between key actors in BF with UNIT-MERIT and CRDI's actors

Existence of other innovation approaches in BF

Content of the approaches,

Similarities and difference with regard to the NIS

At policy makers level

Existence of innovation policy

State of research

State of higher education

Existence of sectoral innovation policy

Agricultural higher education

System performance

Interview guide for Monsanto representatives type of cooperation and partnership that you had during that period before Bt cotton, interests/ advantages

Transitional period: from indigenous to Bt cotton

date of enrolment

Description of the process of your involvement

reasons

Actors in Bt cotton

actors directly in contact with you in BT cotton implementation

type of cooperation

reasons/ interests

actors indirectly in contact with you

type of relationship between you and these other actors

Regulation of Bt cotton

Period of adoption

reasons

changes with Bt cotton policies compare to indigenous cotton

positives

negatives

Linkages and their mechanisms

Mechanisms

Objectives

Set up date

Initiators

Reasons/circumstances

Mode of coordination

Previous mechanisms

Reasons for changes in the mechanisms

Involved actors in the implementation of current mechanisms

Difficulties

Mode of resolution

Support from another actor in the network

Actor’ reaction